U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB80-119795

# Economic Impact Analysis of Hazardous Waste Management Regulations on Selected Generating Industries

Energy Resources Co, Inc, Cambridge, MA

Prepared for

Environmental Protection Agency, Washington, DC Office of Solid Waste

Jun 79

PB80-119795

# ECONOMIC IMPACT ANALYSIS
# OF HAZARDOUS WASTE MANAGEMENT REGULATIONS
# ON SELECTED GENERATING INDUSTRIES

*This report (SW-182c ) describes work performed for the Office of Solid Waste under contract no. 68-01-4819 and is reproduced as received from the contractor. The findings should be attributed to the contractor and not to the Office of Solid Waste.*

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

U.S. ENVIRONMENTAL PROTECTION AGENCY
1979

This report was prepared by Energy Resources Co., Inc. Cambridge, Massachusetts, under contract no. 68-01-4819.

Publication does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of commercial products constitute endorsement by the U.S. Government.

An environmental protection publication (SW-182c ) in the solid waste management series.

**BIBLIOGRAPHIC DATA SHEET**

**1. Report No.**

**2.**

**3. Recipient's Accession No.** PB80-119795

**Title and Subtitle**
Economic Impact Analysis of Hazardous Waste Management
Regulations on Selected Generating Industries

**5. Report Date** June 1979

**6.**

**Author(s)**

**8. Performing Organization Rept. No.**

**Performing Organization Name and Address**
Energy Resources Co. Inc.
185 Alewife Brock Parkway
Cambridge, Mass. 02138

**10. Project/Task/Work Unit No.**

**11. Contract/Grant No.** 68-01-4819

**12. Sponsoring Organization Name and Address**
EPA, Hazardous & Industrial Waste Division
Office of Solid Waste
Washington, D.C. 24060

**13. Type of Report & Period Covered**

**14.** Final

**15. Supplementary Notes**
EPA Project Officer - Joy Wagner

**16. Abstracts**

This report estimates the economic impact of three RCRA Subtitle C regulaory options for potentially hazardous wastes from selected industries. The industries selected were: electric utilities, pulp and paper, gasoline service stations, drum reconditioners, chemical wholesaling, agricultural services and metal and mineral distributors. Estimates of compliance costs, change in net income, plant closures, production losses, job losses, and price increases were made for each of these industries under each of the regulatory options.

**17. Key Words and Document Analysis. 17a. Descriptors**

Resource Conservation and Recovery Act
Hazardous Wastes
Economic Impact Analysis — Subtitle C
Financial Analysis
Electric Utilities
Pulp and Paper
Gasoline Service Stations
Drum Reconditioners
Chemical Wholesaling
Agricultural Services
Metal and Mineral Distributors

**17b. Identifiers/Open-Ended Terms**

**17c. COSATI Field/Group**

**Availability Statement**

**19. Security Class (This Report)** UNCLASSIFIED

**20. Security Class (This Page)** UNCLASSIFIED

**21. No. of Pages** 513

**22. Price** PC A22 MF A01

## CONTENTS

Page

CHAPTER ONE EXECUTIVE SUMMARY 1
- 1.1 Regulatory Background 1
- 1.2 Industry Coverage and Basic Methodology 4
  - 1.2.1 Data Sources for Estimating Compliance Costs 4
  - 1.2.2 Limits of the Analysis 6
- 1.3 Summary of Hazardous Waste Generation 7
- 1.4 Summary of Compliance Costs 9
- 1.5 Summary of Industry Impacts 18

PART I: ELECTRIC UTILITIES

CHAPTER TWO CHARACTERIZATION OF THE ELECTRIC SERVICES INDUSTRY 25
- 2.1 Size and Scope of the Industry 25
  - 2.1.1 Industry Definition 25
  - 2.1.2 Industry Sales 26
  - 2.1.3 Industry Employment 26
  - 2.1.4 Fuel Mix in the Electric Utility Industry 27
  - 2.1.5 Size Distribution of Firms 30
- 2.2 Industry and Market Analysis for Electric Utilities 33
  - 2.2.1 Industry Structure 33
  - 2.2.2 Industry Conduct - The Regulatory Environment for Utilities 35
  - 2.2.3 Industry Performance 37
    - 2.2.3.1 Cost Trends 39
    - 2.2.3.2 Price Trends 41
- 2.3 Financial Trends 42

Preceding page blank

CONTENTS (CONT.)

Page

2.3.1 Earnings and Internal Cash Flows 44
2.3.2 External Financing 47
2.4 Model Plant Descriptors 49
Notes to Chapter Two 50

CHAPTER THREE SOLID WASTE GENERATION IN THE ELECTRIC UTILITY INDUSTRY 51
3.1 Waste Characteristics 52
3.1.1 Coal Ash 52
3.1.1.1 Physical Properties of Ash 53
3.1.1.2 Chemical Constituents 54
3.1.1.3 Trace Element Contents 56
3.1.2 Sludge from Flue-Gas-Desulfurization Systems 59
3.1.2.1 Physical Properties 60
3.1.2.2 Chemical Characteristics of FGD Sludge 61
3.1.2.3 Phase Composition and Trace Elements 62
3.2 Leachate and Solubility Analyses 65
3.2.1 Solubility Analyses 65
3.3 Hazardous Waste Generation from Oil-Burning Power Plants 73
3.3.1 Chemical Makeup of Oil Fly Ash 73
3.4 Other Electric Utility Solid Waste Streams 75
3.4.1 Metal Cleaning Wastes 75
3.4.2 Coal Pile Runoff 76
3.5 Model Plant Waste Quantities 78
3.5.1 Average Oil Ash Quantities 82
3.6 Aggregate Waste Quantities 83
3.7 Number of Generators 85

## CONTENTS (CONT.)

Page

3.8 Current Disposal Practices 85
- 3.8.1 Ash and FGC Sludge Systems 86
- 3.8.2 Ash Disposal 87
- 3.8.3 Commercial Utilization 88

3.9 RCRA Required Treatments 88
- 3.9.1 RCRA Option A - Required Treatments 90
- 3.9.2 RCRA Option B - Required Treatments 91

3.10 Cost Estimates 91
- 3.10.1 Cost Estimation Methodology 94
- 3.10.2 Option A Costs 98
- 3.10.3 Worst-Case Costs 100
- 3.10.4 Option B Costs 104
- 3.10.5 Administrative Costs 107
- Notes to Chapter Three 112

**CHAPTER FOUR ECONOMIC IMPACTS ON THE ELECTRIC UTILITY INDUSTRY** 115

4.1 Model Plant Impacts 115
4.2 Aggregate Cost Impacts 116
4.3 Regional Price Impacts 119
4.4 Secondary Impacts 121
Notes to Chapter Four 123

**PART II: PULP AND PAPER MILLS**

**CHAPTER FIVE CHARACTERIZATION OF THE PULP AND PAPER INDUSTRY** 127

5.1 Size and Scope of the Pulp and Paper Industry 130

## CONTENTS (CONT.)

Page

5.1.1 Pulp 130
5.1.2 Paper 132
5.1.3 Paperboard 139
5.1.4 Building Board 141
5.1.5 Industry Employment 143

5.2 Industry and Market Analysis for the Pulp and Paper Industry 143
5.2.1 Industry Structure 145
5.2.2 Industry Conduct and Performance 147

5.3 Financial Characterization of the Pulp and Paper Industry 150

5.4 Model Plant Descriptions 153

Notes to Chapter Five 158

CHAPTER SIX HAZARDOUS WASTE GENERATION IN THE PULP AND PAPER INDUSTRY 161

6.1 Issues in the Definition of Hazardous Waste Streams 161

6.2 Waste Characteristics 162
6.2.1 Wastewater Treatment Sludges 162
6.2.2 Chemical Pulping Wastes 174
6.2.2.1 Green Liquor Dregs 174
6.2.2.2 Lime Burning Wastes 175
6.2.3 Bark and Wood Wastes 176
6.2.4 Coal and Bark Ash 181
6.2.5 Wastepaper Reclamation Wastes 183
6.2.6 Specialty Product Wastes 184
6.2.7 Miscellaneous Waste Streams 185
6.2.7.1 Evaporator Residues 185
6.2.7.2 Tall Oil Residues 186
6.2.7.3 Parchmentizing 186

CONTENTS (CONT.)

Page

6.3 Solid and Hazardous Waste Quantities 187
  6.3.1 Model Plant Waste Quantities 187
  6.3.2 Waste Stream Quantities 192
    6.3.2.1 Wastewater Treatment Sludge Quantities 192
    6.3.2.2 Chemical Pulping Waste Quantities 192
    6.3.2.3 Coal Ash Quantities 196
    6.3.2.4 Bark and Wood Waste Quantities 198
    6.3.2.5 Secondary Fiber Reclamation Wastes 198
6.4 Number of Generators 199
6.5 Current Disposal Practices 199
6.6 RCRA-Required Disposal Methods 201
6.7 Compliance Costs 202
  6.7.1 Technical Costs 202
  6.7.2 On/Offsite Allocation of Paper Mill Disposal Operations 202
  6.7.3 Administrative Costs 204
  Notes to Chapter Six 208

CHAPTER SEVEN ECONOMIC IMPACTS ON THE PULP AND PAPER INDUSTRY 211
7.1 Model Plant and Worst-Case Impacts 211
7.2 Aggregate Cost Impacts 214
7.3 Industry Impacts 215
  Notes to Chapter Seven 218

# CONTENTS (CONT.)

Page

## PART III: GASOLINE SERVICE STATIONS AND AUTOMOBILE REPAIR SHOPS

CHAPTER EIGHT CHARACTERIZATION OF GASOLINE SERVICE STATIONS AND AUTO REPAIR SHOPS 221

8.1 Gasoline Service Stations 222
  8.1.1 Size and Scope of the Industry 222
    8.1.1.1 Industry Definition 222
    8.1.1.2 Industry Sales 223
    8.1.1.3 Employment 224
    8.1.1.4 Number of Establishments 226
  8.1.2 Industry and Market Analysis 227
    8.1.2.1 Industry Structure 227
    8.1.2.2 Industry Conduct 230
    8.1.2.3 Industry Performance 231
  8.1.3 Financial Characterization 235
    8.1.3.1 Earnings Trends 235
    8.1.3.2 Basic Financial Ratios 236
  8.1.4 Model Firm Characterization 239
8.2 Automotive Repair Shops 241
  8.2.1 Size and Scope of the Industry 241
    8.2.1.1 Industry Definition 241
    8.2.1.2 Industry Sales 242
    8.2.1.3 Industry Employment 243
    8.2.1.4 Size Distribution of Establishments 244
  8.2.2 Industry and Market Analysis 244
    8.2.2.1 Industry Structure 244
    8.2.2.2 Industry Conduct and Performance 246

CONTENTS (CONT.)

Page

8.2.3 Financial Characterization 248

8.2.3.1 Earnings Trends 248

8.2.3.2 Financial Ratios 250

8.2.4 Model Firm Characterization 250

Notes to Chapter Eight 254

CHAPTER NINE WASTE CHARACTERIZATION 257

9.1 Waste Characteristics 257

9.1.1 Identification 257

9.1.2 Characteristics of Waste Oil 257

9.1.3 Other Waste Streams 261

9.1.3.1 Antifreeze 261

9.1.3.2 Solvents 263

9.1.3.3 Batteries 264

9.2 Model Plant Waste Oil Quantities 264

9.2.1 Gasoline Service Stations 265

9.2.2 Automotive Repair Shops 266

9.3 Aggregate Waste Quantities 267

9.3.1 Gasoline Service Station Wastes 267

9.3.1.1 Waste Crankcase Oil Generated at Service Stations 267

9.3.1.2 Crankcase Oil Returned to Service Stations 270

9.3.1.3 Waste Hydraulic Oil Quantities from Gasoline Service Stations 270

9.3.1.4 Total Waste Oil Quantities from Gasoline Service Stations 271

9.3.2 Auto Repair Shops Waste Oil 273

9.3.3 Total Automotive Waste Oil - 1978 273

9.4 Number of Generators 275

9.5 Current Disposal for Waste Oils 277

CONTENTS (CONT.)

Page

9.5.1 Disposal Practices 277
9.5.2 Pricing of Waste Oil 280
9.6 RCRA Specified Disposal 281
9.7 RCRA Compliance Costs 283
9.7.1 Technical Costs - Prices for Waste Oil 283
9.7.2 Administrative Costs - Option A 284
9.7.3 Administrative Costs - Option B 286
Notes to Chapter Nine 287

CHAPTER TEN ECONOMIC IMPACT ASSESSMENT FOR GASOLINE SERVICE STATIONS AND AUTOMOTIVE REPAIR SHOPS 289
10.1 Model Firm Impacts 289
10.1.1 Gasoline Service Stations 289
10.1.2 Automotive Repair Shops 291
10.2 Aggregate National Impacts 294
10.3 Industry Impacts 296
Notes to Chapter Ten 299

PART IV: DRUM RECONDITIONERS

CHAPTER ELEVEN CHARACTERIZATION OF THE DRUM RECONDITIONING INDUSTRY 303
11.1 Size and Scope of the Industry 303
11.1.1 Industry Definition 303
11.1.2 Industry Sales 304
11.1.3 Industry Employment 305
11.1.4 Size Distribution of Firms 305
11.1.5 Regional Distribution of Firms 307

CONTENTS (CONT.)

Page

11.2 Industry and Market Analysis 308
    11.2.1 Industry Structure 310
    11.2.2 Industry Conduct and Performance 314
11.3 Financial Characterization 316
11.4 Model Plant Description 316
    Notes to Chapter Eleven 319

CHAPTER TWELVE HAZARDOUS WASTE GENERATION IN THE DRUM RECONDITIONING INDUSTRY 321
12.1 Process Description 321
12.2 Waste Characteristics 325
12.3 Hazardous Waste Quantities 326
12.4 Number of Generators 330
12.5 Current Disposal Practices 330
12.6 RCRA Required Disposal Practices 333
12.7 Disposal Costs 333
    Notes to Chapter Twelve 335

CHAPTER THIRTEEN ECONOMIC IMPACTS ON THE DRUM RECONDITIONING INDUSTRY 337
13.1 Model Plant Impacts 337
13.2 Aggregate Impacts 339
13.3 Industry Impacts 340

PART V: CHEMICAL WHOLESALING

CHAPTER FOURTEEN CHARACTERIZATION OF THE CHEMICAL WHOLESALING INDUSTRY 345
14.1 Introduction 345

## CONTENTS (CONT.)

Page

14.2 Size and Scope of the Chemical Wholesaling Industry 346

14.2.1 Industry Definition 346

14.2.2 Chemical Wholesaling Sales 347

14.2.3 Employment and Regional Distribution of Firms 350

14.3 Industry and Market Analysis for Chemical Merchant Wholesalers 352

14.3.1 Market Structure 352

14.3.2 Market Conduct and Performance 354

14.4 Financial Profile 355

14.5 Model Firm Characterization 357

Notes to Chapter Fourteen 360

CHAPTER FIFTEEN HAZARDOUS WASTE GENERATION IN THE CHEMICAL WHOLESALING INDUSTRY 361

15.1 Process Description 361

15.2 Waste Characteristics 363

15.2.1 Organic Solvents 364

15.2.2 Acids 364

15.2.3 Caustic Solutions 364

15.3 Model Plant Waste Quantities 365

15.4 Aggregate Waste Quantities 368

15.5 Number of Generators 369

15.6 Current Disposal Practices 370

15.7 RCRA Specified Disposal - Options A and B 371

15.8 Costs of RCRA Compliance 372

15.8.1 Technical Costs of Compliance 372

15.8.2 Administrative Costs of Compliance 374

Notes to Chapter Fifteen 376

## CONTENTS (CONT.)

Page

CHAPTER SIXTEEN ECONOMIC ANALYSIS FOR THE CHEMICAL WHOLESALING INDUSTRY 377

16.1 Model Firm Impacts 377

16.2 Aggregate National Impacts 380

16.3 Industry Impacts 382

Notes to Chapter Sixteen 384

### PART VI: AGRICULTURAL SERVICES

CHAPTER SEVENTEEN CHARACTERIZATION OF THE AGRICULTURAL SERVICES INDUSTRY 387

17.1 The Scope of the Agricultural Services Industry 387

17.1.1 Industry Sales and Growth 390

17.1.2 Distribution of Agricultural Services Among Crops and Among Farm Regions 394

17.1.3 Industry Employment 397

17.1.4 Size Distribution of Firms 398

17.2 Industry and Market Analysis 402

17.2.1 Industry Structure 402

17.2.2 Industry Conduct 404

17.2.3 Industry Performance 404

17.3 Financial Profile 405

17.4 Economics of the Model Firms 405

Notes to Chapter Seventeen 409

CHAPTER EIGHTEEN HAZARDOUS WASTE GENERATION IN THE AGRICULTURAL SERVICES INDUSTRY 411

18.1 Waste Characteristics 411

18.2 Hazardous Waste Quantities 416

18.2.1 Model Firm Waste Quantities 417

CONTENTS (CONT.)

Page

18.2.2 Used Pesticide Containers 417
18.2.3 Waste Pesticides 419
18.2.4 Dilute Pesticide Solutions 420
18.3 Aggregate Waste Quantities 421
18.3.1 Used Container Quantities 421
18.3.2 Waste Pesticides and Dilute Pesticide Solutions 424
18.4 Number of Generators 427
18.5 Current Regulatory Framework 427
18.6 Current Disposal Practices 429
18.6.1 Container Rinsing and Disposal 430
18.6.2 Pesticides and Pesticide Solutions 431
18.7 Disposal Practices Required Under RCRA 436
18.8 Disposal Costs 437
18.8.1 Container Disposal Costs 437
18.8.2 Waste Pesticide Disposal Costs 439
18.8.3 Rinse Water Disposal Costs 439
18.8.4 Administrative Costs 441
Notes to Chapter Eighteen 444

CHAPTER NINETEEN ECONOMIC IMPACT ANALYSIS FOR AGRICULTURAL SERVICES 447
19.1 Model Firm Impacts 447
19.2 Aggregate Costs 450
19.3 Industry Impacts 450
Notes to Chapter Nineteen 454

CONTENTS (CONT.)

Page

## PART VII: METAL AND MINERAL DISTRIBUTIONS

CHAPTER TWENTY HAZARDOUS WASTES IN THE METALS AND MINERALS DISTRIBUTION INDUSTRY 457

20.1 Introduction 457

20.2 SIC 5051: Steel and Ferrous Metals Service Centers 458

20.2.1 Steel Service Center Wastes 459

20.2.2 Waste Properties 461

20.3 Mercury Distributors 461

20.4 Other Primary Metals Wholesalers 462

20.4.1 Toxicity of Wastes 464

20.5 Coal Wholesalers 464

20.5.1 Waste Characterization 465

20.5.2 Regulatory Setting 466

20.6 Metals and Mineral Ores Wholesalers 467

20.7 Conclusions 468

Notes to Chapter Twenty 468

## PART VIII: REGULATORY IMPACTS UNDER RCRA OPTION C

CHAPTER TWENTY-ONE RCRA IMPACTS UNDER OPTION C 473

21.1 Electric Utilities 480

21.2 Pulp and Paper Manufacturers 480

21.3 Gasoline Service Stations and Automotive Repair Shops 482

## CONTENTS (CONT.)

Page

21.4 Drum Reconditioners 486
21.5 Chemical Wholesalers 488
21.6 Agricultural Services 494
21.7 Metal and Mineral Distributors 494

## PART IX: METHODOLOGY

CHAPTER TWENTY-TWO STUDY METHODOLOGY 497
22.1 Model Plant Analysis 497
22.2 Assessment of Industry Impacts 498
22.3 Cost Estimates 500
  22.3.1 Technical Costs 500
  22.3.2 Administrative Costs 500
22.4 Limits of the Analysis 501

## APPENDIX

APPENDIX A COST ESTIMATION METHODOLOGY 505
A.1 Cost of Disposal of Ash and Sludge - Option A 505
A.2 Retrofit Costs for Ash Disposal - Option B 507
A.3 Cost of Dispoal of Ash and Sludge - Option B 512
A.4 Retrofit Costs for Ash Disposal - Option B 512
A.5 Worst-Case Cost Estimates 512
A.6 Aggregate Disposal Costs 512

# CHAPTER ONE

## EXECUTIVE SUMMARY

This report has been prepared in support of the U.S. Environmental Protection Agency's development of an economic impact assessment of anticipated hazardous waste management regulations. The regulations, which will soon be proposed, are authorized by the Resource Conservation and Recovery Act of 1976 (RCRA, PL 94-580). This study involves the examination of three sets of draft RCRA regulations on seven industries which are generators of potentially hazardous wastes.

### 1.1 Regulatory Background

The Resource Conservation and Recovery Act of 1976 authorized EPA to promulgate such regulations for the control of hazardous wastes as may be necessary to protect human health and environment. EPA developed three sets of draft regulations which provide for varying levels of environmental control. These are described below:

> RCRA Option A: Regulations for Enhanced Protection of Public Health and Environment. This set of draft regulations provides for the maximum level of control in the handling and disposal of hazardous wastes.
>
> RCRA Option B: Proposed Actions. This set of draft regulations incorporates a number of modifications to Option A requirements. Most importantly, RCRA Option B provides a modified definition of what constitutes a "hazardous waste." It also proposes separate disposal requirements for certain large-volume "special wastes."

RCRA Option C: Lesser Degree of Public Health and Environmental Protection. This set of regulations seeks to reduce the economic burden of RCRA by (1) exempting several types of waste from consideration, (2) exempting small generators, and (3) reducing the stringency of both technical and administrative procedures.

The EPA first developed Options A and B prior to the development of this report. Option C was not developed until the draft report had been submitted. Accordingly, the first 20 chapters of this report focus only on the impacts of the initial options on the selected industries. Chapter 21 then treats Option C exclusively in light of the analyses performed in the preceding chapters.

An abbreviated comparison of major sections of RCRA Options A and B is provided in Table 1-1. Only several elements which are of particular importance in the assessment of economic impacts are shown in the table. Section 3001, which covers the definition of hazardous wastes, is significantly different between RCRA options. In particular, the test protocol for potentially toxic wastes (The Toxicant Extraction Procedure [TEP]) was modified. Also, some of the toxicity tests, including that for aquatic toxicity, are not included in Option B. Section 3004, under only Option B, provides for definition of separate disposal requirements for "special wastes." These requirements have not been defined to date.

## TABLE 1-1

## A HIGHLIGHT COMPARISON OF RCRA OPTIONS A & B[a]

| REGULATION SECTION | COVERAGE | COMPARISON |
|---|---|---|
| Section 3001 | Definition of Hazardous Waste | Option A provides a toxicity test protocol and several definitions of toxicity. Option B provides a less-stringent testing protocol and omits some of the definitions of toxicity. |
| Section 3002 | Standards Applicable to Generators of Hazardous Wastes | Under Option B, generators of waste oil may transfer much of the cost of compliance to waste oil collectors. This provision is not included in Option A. |
| Section 3004 | Standards Applicable to Hazardous Waste Management Facilities | Under Option A, all hazardous wastes must be handled in facilities which meet the general facility standards. Under Option B, separate requirements are to be defined for "special wastes," including electric utility wastes. |

---

[a] Comparison is based on the RCRA regulations developed to date.

## 1.2 Industry Coverage and Basic Methodology

The six industries covered are shown in Table 1-2. Quite obviously, the industries covered vary from large (electric utilities, the paper industry) to small (chemical warehouses, drum reconditioners). A brief analysis was also made of waste generation among metal and mineral distributors. A summary of findings for that industry is included as Chapter 20.

For each industry, model and worst-case plants (or firms) were developed as an analytical tool. The model plant was defined to be representative of industry firms. Regulatory impacts on this firm are then an indication of impacts on most industry firms. The worst-case plant was defined to represent those plants which will face above-average compliance problems. These impacts are useful in estimating the likelihood of plant closures. The worst-case impacts for most industries are likely to occur at small, economically vulnerable operations, and the worst-case firms have been designed accordingly.

### 1.2.1 Data Sources for Estimating Compliance Costs

The methodology for estimating compliance costs varies by industry. Consistent use was made of the work of two other EPA contractors, Arthur D. Little (Integrated Economic Impact Assessment of Hazardous Waste Management Relations, EPA, October 1978) and Battelle Columbus Laboratories (Cost of Compliance with Hazardous Waste Management Regulations, September 1978). The ADL study was used as the basis for estimating administrative costs (administrative costs are here interpreted to include monitoring and testing, reporting,

TABLE 1-2

SELECTED GENERATING INDUSTRIES

| INDUSTRY | WASTE STREAM | MODEL PLANT | WORST-CASE PLANT |
|---|---|---|---|
| Electric utilities | Coal ash, FGD sludge | 500-MW coal-fired plant | 500-MW coal-fired plant[a] |
| Paper industry | Wastewater treatment sludge, chemical pulping wastes, bark and wood wastes, coal ash, secondary fiber reclamation wastes | 910 MT/day[b] unbleached kraft linerboard mill (virgin fiber) | 360 MT/day folding boxboard mill (secondary fiber) |
| Gasoline service stations | Waste oil | Sales of $345,000 per year | Sales of $246,700 per year |
| Automotive repair shops | Waste oil | Sales of $80,000 per year | Sales of $40,000 per year |
| Drum reconditioners | Process wastes | 1,000 drum/day reconditioning plant | 1,000 drum/day reconditioning plant[a] |
| Chemical warehouses | Repackaging wastes | Sales of $10 million per year | Sales of $5 million per year |
| Agricultural services | Pesticide containers, dilute pesticide solutions and waste pesticides | 3-aircraft aerial applicator (crop dusting) | 1-aircraft aerial applicator (crop dusting) |

[a] Worst-case impacts for these industries were defined as the generation of above-average waste quantities at a medium-sized facility.

[b] MT = metric ton.

training, contingency, and financial responsibility costs). However, a number of judgments had to be made concerning the applicability of various tasks and the costs which would be incurred in the various industries. As a result, the administrative costs should be considered ERCO estimates, based on the definition of tasks as supplied by ADL.

### 1.2.2 Limits of the Analysis

The estimates made in this study were based on data derived from a variety of sources. Each of the estimates and the basic data sources involve some degree of error. No estimation was made of the total probable error range for the cost estimates.

The waste stream designations made are also approximate. Available data in some cases were not sufficient to clearly assign a waste into the "hazardous" or "nonhazardous" category. Conclusions were drawn based upon the existing knowledge. This study was not designed to make a final identification of hazardous wastes in all of the study industries.

The cost estimates provided in this report are based on the "worst-case" assumption that all of the wastes examined are designated as hazardous. Thus all of the cost estimates are contingent upon technical findings about the wastes. This caveat is particularly important to the wastes in the electric utility and pulp and paper where the majority of wastes will be nonhazardous.

This study involves static analysis of the costs of compliance with regulations. It was assumed that access to all necessary treatment or disposal facilities would be available as needed at the estimated price or cost. Thus, for example, no estimation was made of the effect of increased demand due to regulation on the cost of services at hazardous waste facilities. Also no forecast was made of the future availability of such facilities.

No estimate was made of costs to comply with state regulations or federal regulations for nonhazardous waste disposal. The federal regulations are particularly important in that some increase in disposal costs will occur for those wastes designated as nonhazardous. The cost estimates presented here show the increment over current disposal costs. Some fraction of the incremental costs will be incurred even for wastes designated to be nonhazardous. The estimate of this fraction was not made due to the vast uncertainties in interpretation of nonhazardous waste disposal regulations.

## 1.3 Summary of Hazardous Waste Generation

The total hazardous waste generation by the six industries is provided in Table 1-3. The electric utility industry generates by far the largest amount of potentially hazardous wastes.

The total volume of hazardous wastes under the three RCRA options is the same for all industries except pulp and paper. Several large volume wastes generated by pulp and paper mills are likely to be designated hazardous wastes only under RCRA Option A. The waste streams are wastewater treatment sludge, bark, and wood wastes and secondary fiber wastes.

## TABLE 1-3

## HAZARDOUS WASTE GENERATION BY SELECTED INDUSTRIES[a]

| INDUSTRY | HAZARDOUS WASTE GENERATION, 1977 (000 MT) AS DEFINED UNDER OPTION A | AS DEFINED UNDER OPTION B | AS DEFINED UNDER OPTION C |
|---|---|---|---|
| Electric utilities | 64,000 | 64,000 | 0 |
| Pulp and paper | 8,486 | 1,820 | 1,820 |
| Gasoline service stations and automotive repair shops[b] | 1,123 | 1,123 | 1,123 |
| Drum reconditioners | 170 | 170 | 170 |
| Chemical warehouses | 5 | 5 | 5 |
| Agricultural services[b] | 579 | 579 | 579 |

[a] ERCO estimates. It was assumed that the major waste streams examined will be totally designated as hazardous wastes. This assumption is made only for the purpose of estimating costs and is not based on known waste characteristics.

[b] Estimated waste volumes for 1978.

The contribution of each waste stream to total industry wastes is shown in Table 1-4. Coal ash dominates the waste generation picture for electric utilities. Approximately 60 million metric tons (MT) of ash were generated in 1977 compared to roughly 4 million MT of sludge. A small volume of oil ash, which generally has a higher metals content (greater toxicity) than coal ash, was also generated. Coal ash is also generated in the paper industry in the amount of almost 1 million metric tons.

The largest volume waste streams among the other industries are waste oil (1.1 million MT) and dilute pesticide solutions (0.5 million MT). The total hazardous waste production for the drum reconditioning industry and for chemical warehouses was 170,000 MT and 5,000 MT respectively.

## 1.4 Summary of Compliance Costs

Total industry compliance costs under the three RCRA options are shown in Tables 1-5, 1-6, and 1-7. Under Option A compliance costs total $1.1 billion, of which over 75 percent are technical costs and 25 percent are administrative costs. Administrative costs are defined as the sum of monitoring, testing, reporting, training, contingency, and financial responsibility costs. The largest costs are incurred by the electric utilities industry ($606.6 million) and the pulp and paper industry ($354 million). Approximately $110 million in compliance costs would be incurred by gasoline service stations and automotive repair shops combined. The major portion of

## TABLE 1-4
## MAJOR HAZARDOUS WASTE STREAMS FOR SIX INDUSTRIES (1977)[a]

| INDUSTRY | WASTE STREAMS | VOLUME[b] (000 MT) |
|---|---|---|
| Electric utilities | Coal ash | 60,300 |
| | FGD sludge | 3,700 |
| | Oil ash | 20 |
| Pulp and paper | Wastewater treatment sludge[c] | 2,580 |
| | Chemical pulping wastes | 523 |
| | Bark and wood wastes[c] | 2,700 |
| | Coal ash | 978 |
| | Secondary fiber reclamation wastes[c] | 1,694 |
| Service stations and repair shops[d] | | |
| Gas stations | Waste oil | 619 |
| Repair shops | Waste oil | 183 |
| New car and truck dealers | Waste oil | 242 |
| Fleets | Waste oil | 79 |
| Drum reconditioners | Process wastes | 170 |
| Chemical warehouses | Repackaging wastes | 5 |
| Agricultural services[d] | Pesticide containers | 29 |
| | Dilute pesticide solutions and waste pesticides | 550 |

[a] ERCO estimates.

[b] Ash, FGD sludge, and bark quantities are expressed in dry weights.

[c] Wastes are hazardous only under the Option A version of Section 3001.

[d] Estimated waste volumes for 1978.

TABLE 1-5

INDUSTRY INCREMENTAL HAZARDOUS WASTE MANAGEMENT COSTS (OPTION A)[a]

| INDUSTRY | SIC CODE | 1977 PRODUCTION VALUE (1978 $MM) | NUMBER OF GENERATORS AFFECTED | TECHNICAL COMPLIANCE COSTS (1978 $MM) | ADMINISTRATIVE COMPLIANCE COSTS[b] (1978 $MM) | TOTAL COSTS (1978 $MM) | TOTAL COSTS AS A PERCENT OF PRODUCTION VALUE (%) |
|---|---|---|---|---|---|---|---|
| Electric utilities | 4911 | 62,630 | 750 | 484.3 | 122.3 | 606.6 | 1.0 |
| Paper and pulp | 2611<br>2621<br>2631<br>2661 | 40,200 | 561 | 287.4 | 66.6 | 354.0 | 0.9 |
| Gasoline service stations | 5541 | 40,319[c] | 118,530 | 25.6 | 38.4 | 64.0 | 0.2 |
| Automotive repair shops | 753 | 10,352[c] | 66,900 | 10.8 | 21.7 | 32.5 | 0.3 |

---

[a] ERCO estimates. It was estimated for these cost estimates that the major waste streams of interest are designated as hazardous wastes. In practice, small portions of some waste streams will be hazardous.

[b] The administrative cost category includes a variety of costs not directly associated with waste disposal. This category includes reporting, record keeping, ground and surface water monitoring, post closure care, and other compliance activities.

[c] Includes production value only among generators.

TABLE 1-5 (CONT.)

| INDUSTRY | SIC CODE | 1977 PRODUCTION VALUE (1978 $MM) | NUMBER OF GENERATORS AFFECTED | TECHNICAL COMPLIANCE COSTS (1978 $MM) | ADMINISTRATIVE COMPLIANCE COSTS[b] (1978 $MM) | TOTAL COSTS (1978 $MM) | TOTAL COSTS AS A PERCENT OF PRODUCTION VALUE (%) |
|---|---|---|---|---|---|---|---|
| Drum reconditioners | 5085 | 630 | 190 | 7.1 | 0.5 | 7.6 | 1.2 |
| Chemical warehouses | 5161 | 2,700[c] | 360 | 1.1 | 1.0 | 2.1 | 0.1 |
| Agricultural services | 0711<br>0721<br>0729 | 1,900 | 5,300 | 16.2 | 6.3 | 22.5 | 1.2 |
| Totals | | - | 192,591 | 832.5 | 256.8 | 1,089.3 | - |

---

[a] ERCO estimates. It was estimated for these cost estimates that the major waste streams of interest are designated as hazardous wastes. In practice, small portions of some waste streams will be hazardous.

[b] The administrative cost category includes a variety of costs not directly associated with waste disposal. This category includes reporting, record-keeping, ground and surface water monitoring, post-closure care, and other compliance activities.

[c] Includes production value only among generators.

## TABLE 1-6

## INDUSTRY INCREMENTAL HAZARDOUS WASTE MANAGEMENT COSTS (OPTION B)[a]

| INDUSTRY | SIC CODE | 1977 PRODUCTION VALUE (1978 $MM) | NUMBER OF GENERATORS AFFECTED | TECHNICAL COMPLIANCE COSTS (1978 $MM) | ADMINISTRATIVE COMPLIANCE COSTS[b] (1978 $MM) | TOTAL COSTS (1978 $MM) | TOTAL COSTS AS A PERCENT OF PRODUCTION VALUE (%) |
|---|---|---|---|---|---|---|---|
| Electric utilities | 4911 | 62,630 | 750 | 0.0 | 44.2 | 44.2 | 0.1 |
| Paper and pulp | 2611<br>2621<br>2631<br>2661 | 40,200 | 561 | 68.6 | 17.9 | 86.5 | 0.2 |
| Gasoline service stations | 5541 | 40,319[c] | 118,530 | 25.6 | 8.8 | 34.4 | <0.1 |
| Automotive repair shops | 753 | 10,352[c] | 66,900 | 10.8 | 5.0 | 15.8 | 0.2 |

[a] ERCO estimates. It was estimated for these cost estimates that the major waste streams of interest are designated as hazardous wastes. In practice, small portions of some waste streams will be hazardous.

[b] The administrative cost category includes a variety of costs not directly associated with waste disposal. This category includes reporting, record-keeping, ground and surface water monitoring, post-closure care, and other compliance activities.

[c] Includes production value only among generators.

TABLE 1-6 (CONT.)

| INDUSTRY | SIC CODE | 1977 PRODUCTION VALUE (1978 $MM) | NUMBER OF GENERATORS AFFECTED | TECHNICAL COMPLIANCE COSTS (1978 $MM) | ADMINISTRATIVE COMPLIANCE COSTS[b] (1978 $MM) | TOTAL COSTS (1978 $MM) | TOTAL COSTS AS A PERCENT OF PRODUCTION VALUE (%) |
|---|---|---|---|---|---|---|---|
| Drum reconditioners | 5085 | 630 | 190 | 7.1 | 0.4 | 7.5 | 1.2 |
| Chemical warehouses | 5161 | 2,700[c] | 360 | 1.1 | 0.9 | 2.0 | 0.1 |
| Agricultural services | 0711<br>0721<br>0729 | 1,900 | 5,300 | 16.2 | 5.5 | 21.7 | 1.1 |
| Totals |  | - | 192,591 | 129.4 | 82.7 | 212.1 | - |

[a] ERCO estimates. It was estimated for these cost estimates that the major waste streams of interest are designated as hazardous wastes. In practice, small portions of some waste streams will be hazardous.

[b] The administrative cost category includes a variety of costs not directly associated with waste disposal. This category includes reporting, record-keeping, ground and surface water monitoring, post-closure care, and other compliance activities.

[c] Includes production value only among generators.

TABLE 1-7

INDUSTRY INCREMENTAL HAZARDOUS WASTE MANAGEMENT COSTS (OPTION C)[a]

| INDUSTRY | SIC CODE | 1977 PRODUCTION VALUE (1978 $MM) | NUMBER OF GENERATORS AFFECTED | TECHNICAL COMPLIANCE COSTS (1978 $MM) | ADMINISTRATIVE COMPLIANCE COSTS[b] (1978 $MM) | TOTAL COSTS (1978 $MM) | TOTAL COSTS AS A PERCENT OF PRODUCTION VALUE (%) |
|---|---|---|---|---|---|---|---|
| Electric utilities | 4911 | 62,630 | 0 | – | – | – | – |
| Paper and pulp | 2611<br>2621<br>2631<br>2661 | 40,200 | 561 | 68.6 | 11.8 | 80.4 | 0.2 |
| Gasoline service stations | 5541 | 40,319[c] | 13,170 | 13.8 | 1.0 | 14.8 | <0.5 |
| Automotive repair shops | 753 | 10,352[c] | 6,690 | 5.6 | 0.5 | 6.1 | <0.1 |

---

[a] ERCO estimates. It was estimated for these cost estimates that the major waste streams of interest are designated as hazardous wastes. In practice, small portions of some waste streams will be hazardous.

[b] The administrative cost category includes a variety of costs not directly associated with waste disposal. This category includes reporting, record-keeping, ground and surface water monitoring, post-closure care, and other compliance activities.

[c] Includes production value only among generators.

TABLE 1-7 (CONT.)

| INDUSTRY | SIC CODE | 1977 PRODUCTION VALUE (1978 $MM) | NUMBER OF GENERATORS AFFECTED | TECHNICAL COMPLIANCE COSTS (1978 $MM) | ADMINISTRATIVE COMPLIANCE COSTS[b] (1978 $MM) | TOTAL COSTS (1978 $MM) | TOTAL COSTS AS A PERCENT OF PRODUCTION VALUE (%) |
|---|---|---|---|---|---|---|---|
| Drum reconditioners | 5085 | 630 | 190 | 7.1 | 0.4 | 7.5 | 1.2 |
| Chemical warehouses | 5161 | 2,700[c] | 270 | 0.5 | 0.5 | 1.1 | <0.05 |
| Agricultural services | 0711<br>0721<br>0729 | 1,900 | 0 | - | - | - | - |
| Totals | | - | 20,881 | 95.6 | 14.2 | 109.9 | - |

---

[a] ERCO estimates. It was estimated for these cost estimates that the major waste streams of interest are designated as hazardous wastes. In practice, small portions of some waste streams will be hazardous.

[b] The administrative cost category includes a variety of costs not directly associated with waste disposal. This category includes reporting, record-keeping, ground and surface water monitoring, post-closure care, and other compliance activities.

[c] Includes production value only among generators.

Option A compliance costs under these industries are administrative costs. Total compliance costs equal approximately 1 percent of 1977 production value in all industries.

Compliance costs under RCRA Option B are substantially lower, although this is partly due to the interpretation given to the existing draft regulations. In particular, technical compliance costs for electric utilities have been set at zero, pending the definition of facility standards for utility wastes. Costs are also significantly lower for the pulp and paper industry. The reduction is due to the likelihood of a "nonhazardous" label for most of the industry's wastes under RCRA Option B. Administrative costs for gasoline service stations and auto repair shops are also lower under Option B. Overall, RCRA Option B compliance costs for these six industries are $212 million.

RCRA Option C not only offers a dramatic reduction in cost, but also exempts large numbers of plants from the regulation. Total compliance cost for the selected industries under Option C is $109.9 million - nearly 50 percent of the total costs for Option B and only 10 percent of the cost of Option A. Nearly 90 percent of this cost is for technical disposal. The number of generators covered under Option C is only 20,881, only 11 percent of the 192,591 plants covered under Options A and B.

## 1.5 Summary of Industry Impacts

The expected decline in net income (pretax) for the model and worst-case plants in each industry are shown in Table 1-8. These calculations were made under the assumption that no price change occurs which allows the firms to pass through compliance costs. Large declines in net income were noted for the agricultural services and drum reconditioning industries. Relatively small changes were noted for the model and worst-case plants in other industries. No numerical estimate was made of the decline in net income for the model plant in the electric utility industry. The regulatory process for electric utilities was not formally modelled, but the effect of RCRA on net income would, in all likelihood, be small. A small decline in net income would be expected due to the effect of normal regulatory lag on the ability of utilities to recover costs.

The overall industry impacts on Options A and B are presented in Table 1-9. In these estimates, the likelihood of price increases and other factors were considered. The following definitions were used in defining the likelihood of plant closure: (1) "unlikely" means there is estimated to be less than a 25 percent chance that 10 percent of the industry plants will close, (2) "possible" means there is a 25 to 50 percent chance that 10 percent of the industry plants will close, and (3) "probable" means there is a 50 to 75 percent chance that 10 percent of the industry plants will close. Price increases, all of which were estimated to be 3 percent or less, were defined as small.

TABLE 1-8

MODEL PLANT IMPACTS UNDER RCRA OPTIONS A AND B[a,b]

| INDUSTRY | % DECLINE IN NET INCOME | | | | | |
|---|---|---|---|---|---|---|
| | OPTION A | | OPTION B | | OPTION C | |
| | MODEL | WORST-CASE | MODEL | WORST-CASE | MODEL | WORST-CASE |
| Agricultural services | 24 | 46 | 23 | 44 | - | - |
| Drum reconditioners | 23 | 37 | 23 | 36 | 23 | 36 |
| Paper and pulp (kraft mill) | 3 | 5 | 2 | 3 | 2 | 3 |
| Gasoline service stations | 3 | 15 | 8 | 9 | c | c |
| Automotive repair shops | 9 | 6 | 2 | 3 | c | c |
| Chemical warehouses | 1 | 4 | 1 | 3 | 1 | 3 |

[a] ERCO estimates.

[b] No numerical assessment of the change in model plant net income for electric utilities was made. Small impacts would be expected due to regulatory lag.

[c] Small gasoline service stations and automotive service stations will be exempted from Option C. Therefore, the model plant fails to reflect the larger size and accompanying improved financial position of the average firm covered by Option C. It can be assumed that these larger plants will face smaller declines than those faced in Option B, but no quantitative estimate has been developed.

## TABLE 1-9

## POTENTIAL INDUSTRY IMPACT OF RCRA - OPTIONS A AND B[a,b]

| INDUSTRY | NUMBER OF HAZARDOUS WASTE GENERATORS | PLANT CLOSURES | JOB LOSSES | PRO-DUCTION CUTBACKS | PRICE INCREASES | U.S. DEMAND REDUCTION | BALANCE OF PAYMENTS EFFECTS |
|---|---|---|---|---|---|---|---|
| Electric utilities | 750 | Unlikely | Unlikely | Unlikely | Small | Small | Slight import increase |
| Paper and pulp | 561 | Unlikely | Unlikely | Unlikely | Small | Small | None |
| Gasoline service stations | 131,700 | Unlikely | Unlikely | Unlikely | Small | Small | None |
| Automotive repair shops | 138,300 | Unlikely | Unlikely | Unlikely | Small | Small | None |
| Drum recon-ditioners | 190 | Possible | Possible | Unlikely | Small | Small | None |
| Chemical warehouses | 360 | Unlikely | Unlikely | Unlikely | Small | Small | None |
| Agricultural services | 5,300 | Probable | Probable | Unlikely | Small | Small | None |

[a] ERCO estimates.

[b] Potential impacts as defined here are the same for both RCRA options.

Plant shutdowns appear most likely in the agricultural services industry. This industry includes a large number of small, economically vulnerable firms. Plant shutdowns are also possible in the drum reconditioning industry, as indicated by the estimated drop in net income for the model and worst-case plants. However, strong market conditions for this industry make it less likely that many firms will cease operations. Impacts on other industries should be small. Some plant closures could occur in the pulp and paper industry under RCRA Option A. However, it is extremely unlikely that 10 percent of the industry's mills would close.

No production cutbacks were forecast. Plant closures, where they occur, will be due to the combined influences of competitive and regulatory pressures. Remaining industry firms should, therefore, be able to handle the market demand.

A slight import increase is seen from the electric utility industry as a result of RCRA. The increase should occur from those utilities which are equipped to burn both coal and oil. In 1977, there were 96 utilities which burned coal and at least 100,000 barrels of oil. Some firms may increase oil purchases due to the added expense of coal ash disposal.

Option C will exempt the agricultural services industry, removing any chance of plant shutdowns in this industry due to RCRA regulations. Also, compliance costs for drum reconditioners will not change materially under Option C, but cost reductions in the pulp and paper industry and the exemption of all utilities should help preclude significant impact in these industries.

# PART I

# ELECTRIC UTILITIES

## CHAPTER TWO

# CHARACTERIZATION OF THE ELECTRIC SERVICES INDUSTRY

An overview of the electric utility industry is provided in this chapter. The topics covered include the size and scope of the industry, the industry structure, and the financial characterization.

## 2.1 Size and Scope of the Industry

### 2.1.1 Industry Definition

The electric services industry, as defined by SIC code 4911, includes establishments engaged in the generation, transmission, and/or distribution of electric energy for sale. For this study, only the electrical generation segment of the industry will be examined because it is this portion of the industry that generates the potentially hazardous waste materials of interest here. Principal attention will be focused on coal-burning utilities for the obvious reason that these plants produce the overwhelming bulk of the potentially hazardous waste materials affected by RCRA regulations. Oil-burning utilities will, however, be briefly examined to determine their contribution to the problem. Nuclear power plants will not be examined in this study.

**Preceding page blank**

### 2.1.2 Industry Sales

The electric utility industry is one of the largest U.S. industries and has been one of the fastest growing. Over the past 12 years (1965 to 1977) electrical generation has doubled. Total industry revenues in the same period have quadrupled, reflecting increased sales and costs. The industry requires extremely large volumes of capital spending. In 1978, capital expenditures for generation, transmission, and distribution are expected to total $33 billion. Thus, the industry fortunes have a significant effect on the economy and on national capital markets.

Recently, however, industry growth has been moderated by deferrals and/or cancellations of large power-generating facilities. Several factors have contributed to the reduced growth including concerns about energy conservation, uncertainties about federal energy and environmental policies, and difficulties in the siting of nuclear power facilities. The growth of generating capacity has slowed in recent years as shown below in Table 2-1.

### 2.1.3 Industry Employment

The total employment in the electric utility industry is 362,500. However, only a small percentage of these employees actually work in generating plants. Generating facilities are capital-intensive and utilize minimal labor. Most people employed by the industry work either in administrative capacities or in the transmission and distribution end of the business which will be relatively unaffected by these regulations.

. TABLE 2-1

GROWTH OF GENERATING CAPACITY[a]

| YEAR | TOTAL INSTALLED GENERATING CAPACITY (000 kW) | % ANNUAL GROWTH OVER PREVIOUS YEAR |
|---|---|---|
| 1977 | 576,336 | 4.7 |
| 1976 | 550,611 | 4.4 |
| 1975 | 527,591 | 6.5 |
| 1974 | 495,519 | 7.9 |
| 1973 | 459,252 | 9.7 |
| 1972 | 418,457 | 7.7 |
| 1971 | 388,377 | - |

[a] Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1976.

### 2.1.4 Fuel Mix in the Electric Utility Industry

Coal is the most extensively used fuel source in the electric utility industry, and it is expected to remain so into the future. Electric generation by each of the principal fuel types is shown in Table 2-2. For 1977, coal-burning utilities generated slightly more than half of the country's electricity. The remaining fuel use was divided among oil (18.8 percent), gas (16.1 percent), and nuclear (13.2 percent). As can be seen from the table, the percentage of the total electrical energy attributable to coal use has fallen since 1965 when coal accounted for two-thirds of the nation's total. In the same period, the use of oil and nuclear fuels increased substantially. However, current projections indicate that coal use will not decline further. One such projection, made by Edison Electric Institute, shows the percentage of total power generated from coal remaining very stable through 1986.[1]

TABLE 2-2

GENERATION, BY FUEL TYPE[a]

| YEAR | TOTAL THERMAL GENERATION[b] | COAL | | OIL | | GAS | | NUCLEAR | |
|---|---|---|---|---|---|---|---|---|---|
| | | MM kWh | % OF TOTAL | MM kWh | % OF TOTAL | MM kWh | % OF TOTAL | MM kWh | % OF TOTAL |
| 1977[c] | 1,899,527 | 985,443 | 51.9 | 357,849 | 18.8 | 305,353 | 16.1 | 250,882 | 13.2 |
| 1976[c] | 1,748,914 | 943,877 | 54.0 | 319,499 | 18.3 | 294,427 | 16.8 | 191,111 | 10.9 |
| 1975 | 1,614,117 | 852,972 | 52.8 | 288,873 | 17.9 | 299,766 | 18.6 | 172,506 | 10.7 |
| 1970 | 1,283,271 | 706,102 | 55.0 | 182,488 | 14.2 | 372,884 | 29.1 | 21,797 | 1.7 |
| 1965 | 860,940 | 570,926 | 66.3 | 64,801 | 7.5 | 221,559 | 25.8 | 3,657 | 0.4 |

[a] Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1976, p. 22, and "Advance Release of Data for the Statistical Year Book of the Electric Utility Industry - Year 1977."

[b] Excludes generation by geothermal wood and waste.

[c] Preliminary figure.

The importance of coal, and therefore the importance of environmental regulations on coal burning, varies significantly among regions. The breakdown of fuel use by region is shown in Table 2-3. Dependence on coal is highest for utilities in the East North Central, East South Central, West North Central, and Mountain states. These regions cover the entire Midwest, the Far West states, except for the Pacific coast states, and the southern states of Mississippi, Alabama, Tennessee and Kentucky. Coal-burning utilities account for two-thirds of the total generation in these

TABLE 2-3

GENERATION, BY FUEL TYPE AND BY REGION, 1976[a]

| REGION | TOTAL THERMAL GENERATION (MM kWh) | % OF GENERATION | | | |
|---|---|---|---|---|---|
| | | COAL | OIL | GAS | NUCLEAR |
| New England | 70,626 | 3 | 61 | - | 36 |
| Middle Atlantic | 219,398 | 49 | 34 | 1 | 16 |
| East North Central | 370,736 | 81 | 4 | 2 | 13 |
| West North Central | 127,578 | 68 | 4 | 14 | 14 |
| South Atlantic | 352,446 | 59 | 24 | 4 | 13 |
| East South Central | 164,235 | 90 | 5 | 2 | 3 |
| West South Central | 242,245 | 6 | 6 | 86 | 2 |
| Mountain | 89,223 | 78 | 6 | 16 | - |
| Pacific | 104,524 | 6 | 57 | 28 | 9 |
| Alaska and Hawaii | 7,903 | 4 | 77 | 19 | - |

[a] Federal Power Commission, Statistical Year Book, Edison Electric Institute, p. 23.

states. Coal use is also high in the Middle and South Atlantic states (49 percent and 59 percent). Coal use is very low for the remaining regions, where oil or gas are the chief fuel sources. These areas include New England, the Gulf states, the Pacific coast, Alaska and Hawaii.

A different view of the industry can be formulated when electrical generation is classified according to the type of generator used. Most of the country's electricity is derived from steam-driven generators. In 1977, 78 percent of the total electricity supply was provided by steam plants. The remaining supply was divided among hydroelectric generators (10 percent), nuclear-driven generators (12 percent), and internal combustion engines (less than 1/2 of 1 percent).[2]

### 2.1.5 Size Distribution of Firms

The growth in demand for electric power has been met by increases in the average size of power plants. Statistics on the size distribution of steam electric power plants (private only) are displayed in Table 2-4 for the years 1965, 1970, and 1975. From 1965 to 1975, the total number of steam electric plants fell slightly while generating capacity more than doubled. The shift toward larger plants is shown most dramatically by the increase in the number of plants with over 1,000 MW of capacity from 17 in 1965 to 90 in 1975. By 1975, 35 percent of the operating plants exceeded 500 MW of capacity. In 1965, only 14 percent of the plants had a capacity greater than 500 MW.

The increasing plant size is due to the increased number of generating units per plant and the increasing size of

## TABLE 2-4

## PLANTS, BY GENERATING CAPACITY FOR PRIVATELY OWNED FOSSIL-FUELED STEAM PLANTS[a]

| | | MW | | | | |
|---|---|---|---|---|---|---|
| YEAR | TOTAL NO. OF PLANTS | LESS THAN 100 | 100 TO 500 | 501 TO 1,000 | OVER 1,000 | TOTAL CAPACITY |
| 1975 | 631 | 154 | 255 | 132 | 90 | 366,504 |
| 1970 | 661 | 219 | 287 | 108 | 47 | 220,536 |
| 1965 | 653 | 255 | 309 | 72 | 17 | 159,141 |

[a] Federal Power Commission, Statistics of Privately Owned Electric Utilities in the United States, years indicated.

individual units. Utilities are able to save on the capital and operating costs per kilowatt hour of power supplied in each case due to economies of scale in construction and operation.

The trend toward larger size is expected to continue. In Table 2-5, the current schedule for new orders of fossil-fired boilers through 1990 is displayed. Average capacity for the new units rises significantly through 1990. In addition to the cost savings from larger plants and units, the movement has also been encouraged by the advance of nuclear power. Nuclear units are most economical in large generating sizes. Makers of fossil-fired boilers have strived to increase the efficient size of their units in order to stay competitive on a cost per kilowatt (of capacity) basis. The growth of power pools, that is, arrangements where several utilities agree to coordinate their power supply activities, has also facilitated the move to larger unit sizes. The power pools allow utilities greater

## TABLE 2-5

## SCHEDULED NEW CAPACITY FROM FOSSIL-FIRED BOILER UNITS[a]

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 & BEYOND |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of units scheduled for commercial service | 26 | 42 | 35 | 39 | 27 | 25 | 24 | 16 | 14 | 19 | 8 | 9 | 3 | 3 | 5 |
| Average MWe capacity | 450 | 443 | 431 | 484 | 528 | 580 | 607 | 505 | 584 | 519 | 623 | 637 | 692 | 600 | 680 |
| % of capacity which is coal-burning[b] | 78 | 64 | 82 | 87 | 91 | 95 | 90 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

---

[a] "1977 Fossil Boiler Survey," Electrical World, March 1, 1977, pp. 35-38.

[b] Includes units which are fuel flexible, i.e., can burn other fuels in dition to coal.

flexibility in the use of their generating capacity. In general, the large units can be used to supply base load power demand and small units switched on and off to meet peak load power demand. Such an arrangement provides important operating cost savings to utilities.

## 2.2 Industry and Market Analysis for Electric Utilities

### 2.2.1 Industry Structure

The electric utility industry encompasses both private and publicly owned utility firms. The industry, however, is dominated by private or investor-owned utilities. The breakdown of industry firms by ownership type is shown in Table 2-6, along with aggregate statistics on electric power generation for the industry. As can be calculated from the table, the private utilities generated 79 percent of the total industry production for 1977. Furthermore, the role of private utilities has remained fairly constant over time. In 1965, private utilities produced 75 percent of the total U.S. electrical production.

The next largest utility group includes the federally owned utilities accounting for 10.1 percent of production in 1977. This group includes the nation's largest system, the Tennessee Valley Authority (TVA), and other federal systems including the Bonneville Power Administration and the Bureau of Reclamation (Department of Interior) system. The federal systems sell most of their electric power to other publicly owned systems, or to a few large industrial purchasers. The other publicly owned systems are municipal systems, state projects, and public power districts.

TABLE 2-6

GENERATION BY THE ELECTRIC UTILITY INDUSTRY, BY TYPE OF OWNERSHIP
(MM kWh)[a]

| | | | PUBLICLY OWNED | | | |
|---|---|---|---|---|---|---|
| YEAR | INVESTOR-OWNED UTILITIES | REA COOPERA-TIVES | MUNICIPAL UTILITIES | FEDERAL | POWER DISTRICTS, STATE PROJECTS | TOTAL |
| 1977[b] | 1,683,794 | 45,126 | 83,305 | 213,618 | 98,183 | 2,124,026 |
| 1976[b] | 1,582,022 | 40,549 | 77,806 | 235,908 | 100,218 | 2,036,503 |
| 1975 | 1,486,844 | 35,328 | 81,518 | 221,226 | 92,703 | 1,917,619 |
| 1970 | 1,183,190 | 23,459 | 71,394 | 185,753 | 67,813 | 1,513,609 |
| 1965 | 809,474 | 8,571 | 49,940 | 145,231 | 42,036 | 1,055,252 |

[a] Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1976, p. 18, and "Advance Release of Data for the Statistical Year Book of the Electric Utility Industry - Year 1977."

[b] Preliminary figure.

The remaining utility group consists of electric service cooperatives funded by the Rural Electrification Administration. The cooperatives supply power in remote areas where the population is so sparse as to cause high distribution costs per customer. In these areas, the necessary investments were not profitable for private industry and federal financing was necessary. The REA cooperatives generated 2 percent of the nation's power in 1977.

### 2.2.2 Industry Conduct - The Regulatory Environment for Utilities

Because of the inherent efficiency of a monopoly structure for electric services, private and public utilities are granted local monopoly power and then controlled by regulatory agencies. The purpose of the controls is to prevent utilities from obtaining monopoly profits while at the same time yielding a fair rate of return on investments, and also to avoid unduly discriminatory rates and ensure adequate and reliable service. The state regulatory agencies control the sale of electricity to ultimate consumers, and the Federal Energy Regulatory Commission controls the rates on wholesale electricity sold across state lines.

When an electric utility files for a rate increase, the matter is typically settled by the state regulatory agency within the format of an adjudicatory proceeding, that is, a rate case. The rate case is divided into two parts. The "revenue requirement," or what the utility is allowed to earn, is established first; the rate schedules are then approved to meet the revenue requirement.

The revenue requirement is usually expressed in formula form as follows:

$RR = E + d + T + (V-D)R$, in which

$RR$ = Revenue requirement
$E$ = Operating expenses
$d$ = Annual depreciation expense
$T$ = Taxes, including income taxes
$V$ = Gross valuation of the property
$D$ = Accrued depreciation
$R$ = Rate of return
$(V-D)$ = Rate base (net valuation)
$(V-D)R$ = Return amount of profit, expressed as earnings allowed on the rate base.

In most instances, data used in the rate case are taken from the past 12 months of operations. The recent problem for utilities has been cost inflation beyond that anticipated. Even the substantial rate increases of recent years have often failed to cover the rapidly increasing revenue requirements. The problem is aggravated by the time lag involved in the rate case process itself. The hearing process requires 6 months to a year, but of late the process has been more drawn out due to the large number of utilities seeking increases. The increase in the backlog of rate cases as counted at year end grew from 59 percent in 1970 to 185 percent in 1975.[3]

The combined effect of cost inflation and the regulatory lags has caused a decline in the rate of return on equity for the industry. The distribution of firms along the spectrum of possible returns is shown in Table 2-7. The decline in returns is not catastrophic but is significant.

TABLE 2-7

DISTRIBUTION OF RETURN ON EQUITY FOR INVESTOR-OWNED UTILITIES, 1970 AND 1975[a]

| RETURN ON EQUITY (%) | 1970 | 1975 |
|---|---|---|
| Less than 5 | 2.4 | 5.7 |
| 5 to 7.9 | 17.9 | 14.8 |
| 8 to 10.9 | 27.1 | 31.0 |
| 11 to 13.9 | 32.3 | 37.1 |
| 14 to 16.9 | 16.4 | 9.5 |
| 17 and above | 3.9 | 1.9 |

[a] Federal Power Commission, Statistics of Privately Owned Electric Utilities in the United States.

The percentage of industry firms earning less than a 5 percent rate of return more than doubled between 1970 and 1975. At the other end of the scale, the number of firms earning more than 14 percent had fallen from 20.3 percent to 11.4 percent. These figures have led to a weakening of the industry's balance sheets, and to problems in obtaining needed financing. These problems are discussed below.

### 2.2.3 Industry Performance

Before presenting the recent cost and price trends for the industry, it is useful to examine the basic cost structure for the industry. The basic cost components, presented as a percentage of total operating revenue, are shown in Table 2-8. The table includes data on private utilities, federal power projects, and municipal wholesalers and retailers. As expected, power production costs are the

## TABLE 2-8

## COST STRUCTURE FOR ELECTRIC UTILITIES[a]

| COST ACCOUNT | % OF TOTAL UTILITY OPERATING REVENUE | | | |
|---|---|---|---|---|
| | INVESTOR-OWNED | MUNICIPAL WHOLESALERS | MUNICIPAL RETAILERS | FEDERAL PROJECTS |
| Power production | 46 | 41 | 56 | 56 |
| Fuel | 33 | - | - | - |
| Purchased power | 7 | - | - | - |
| Other power production | 3 | - | - | - |
| Maintenance | 3 | - | - | - |
| Transmission | 1 | 3 | 1 | 5 |
| Distribution | 4 | 1 | 6 | 0 |
| Customer accounting and sales | 2 | 1 | 3 | 0 |
| Administrative and general | 2 | 5 | 5 | 3 |
| Total operation and maintenance | 58 | 51 | 71 | 64 |
| Other costs (depreciation, taxes) | 23 | 10 | 12 | 11 |
| Total operating costs | 81 | 61 | 83 | 75 |
| Utility operating income | 19 | 39 | 17 | 25 |
| Total utility operating revenue | 100 | 100 | 100 | 100 |

[a] Federal Power Commission, Statistics of Privately Owned Electric Utilities in the United States, 1975.

largest expense. They account for 46 percent of total operating revenue for private firms, and as high as 56 percent for both municipal retailers and federal projects. For municipal retailers, the power production costs include the higher costs of purchased power. Transmission and distribution costs are a small portion of operating expenses. The highest distribution costs are borne by municipal retailers due to the distribution-oriented operations of these companies. A large difference between the private and public utilities is evident in the depreciation and taxes account. The FPC data indicate that 23 percent of private operating revenue was expensed in this account compared to 10 to 12 percent for public utilities. The different tax status combined with the smaller asset value of public firms is the reason for the larger spread.

### 2.2.3.1 Cost Trends

Utilities have faced significant cost increases particularly in expenditures for construction, fuel, and labor. The trend in construction costs, as indicated by the Handy-Whitman Index for utility construction, is displayed in Table 2-9. The index nearly doubled from 1970 to 1977, representing an average annual rate of increase of approximately 10 percent.

Fuel wholesale price indices have risen even more steeply than the construction cost index. The price indices for coal, petroleum products, and gas are shown in Table 2-10. The index for each fuel more than doubled between 1970 and 1975. The average annual rates of growth in the period were 21 percent for coal, 21 percent for petroleum products, and 16 percent for gas.

## TABLE 2-9

## COST TRENDS OF ELECTRIC POWER AND LIGHT CONSTRUCTION, HANDY-WHITMAN INDEX[a],[b]

| YEAR[c] | INDEX VALUE[d] |
|---|---|
| 1977 | 385 |
| 1976 | 367 |
| 1975 | 341 |
| 1974 | 276 |
| 1973 | 249 |
| 1972 | 241 |
| 1971 | 217 |
| 1970 | 203 |
| 1965 | 164 |

---

[a] Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1976, p. 68.

[b] 1949 = 100.

[c] Measured on January 1 of the year.

[d] The figures presented are for North Atlantic geographic area. All geographic regions have had similar rates of cost increase.

### TABLE 2-10

### FUEL WHOLESALE PRICE INDICES[a,b]

| YEAR | WPI: COAL | WPI: PETROLEUM PRODUCTS, REFINED | WPI: GAS FUELS |
|---|---|---|---|
| 1975 | 385.8 | 257.5 | 216.7 |
| 1974 | 332.4 | 223.4 | 162.2 |
| 1973 | 218.1 | 128.7 | 126.7 |
| 1972 | 193.8 | 108.9 | 114.1 |
| 1971 | 181.8 | 106.8 | 108.0 |
| 1970 | 150.3 | 101.0 | 103.6 |
| 1965 | 93.4 | 93.8 | 92.8 |

---

[a] U.S. Bureau of Labor Statistics, Wholesale Price and Price Indexes, 1976.

[b] 1967 = 100.

The 1970 to 1975 period produced an increase in total salaries and wages for the industry of 50 percent. In the same time period, total electricity generated increased only 25 percent and the number of employees increased 4.8 percent.[4] The consumer price index in the same period rose 40 percent. It is apparent that the increase in labor costs to utilities was fueled by the general inflation, and that the increase was more rapid than the rise in productivity.

#### 2.2.3.2 Price Trends

The price trends have followed the cost trends in a steady, upward path. The increases have been slightly greater than those of the consumer price index for the 10-year period 1967-77, as shown in Table 2-11. The electricity price index grew 90 percent in that period, compared with 83 percent of the consumer price index. It is noteworthy that more than half of the growth for the index took place in the final 4 years of the period, 1973 through 1977. Since 1973, electricity prices have grown at an average annual rate of 10 percent per year.

The growth of electricity prices has varied widely among regions depending largely upon the varying availability of fuel within each region. The percentage increase in average electricity bills for each customer class is shown in Table 2-12. Residential consumers in the New England, Pacific, South Atlantic, and East South Central states (the latter two categories cover the eastern seaboard except for New York, New Jersey, and the other southern states east of Louisiana and Arkansas) received the largest increases. The smallest increases occurred in the southwestern (West South Central), Mountain, and Middle Atlantic States.

## 2.3 Financial Trends

The financial position of utilities has declined in recent years due to the effect of the regulatory lag (discussed above) on their ability to recover costs and thus to maintain the industry rate of return. With this change in fortunes, the industry has found increasing difficulty in raising funds. Internal cash flows are inadequate for financing investment, and fund raising in national capital markets has become increasingly expensive for the industry. As a result, the balance sheet position for the industry is significantly weaker than it was a decade ago. In the

## TABLE 2-11

## ELECTRICITY PRICE AND CONSUMER PRICE INDICES[a]

| YEAR | ELECTRICITY PRICE INDICES | CONSUMER PRICE INDICES |
|---|---|---|
| 1977 | 190.7 | 186.1 |
| 1976 | 182.4 | 174.3 |
| 1975 | 171.4 | 166.3 |
| 1974 | 157.5 | 155.4 |
| 1973 | 129.0 | 138.5 |
| 1972 | 120.2 | 127.3 |
| 1971 | 116.0 | 123.1 |
| 1970 | 109.9 | 119.1 |
| 1969 | 104.2 | 112.9 |
| 1968 | 101.0 | 106.4 |
| 1967 | 100.5 | 101.6 |

[a] U.S. Bureau of Labor Statistics, Wholesale Price and Price Indexes, 1976.

## TABLE 2-12

## PERCENT INCREASE IN AVERAGE ELECTRICITY BILLS, BY CENSUS REGION AND CUSTOMER CLASS, 1965 to 1975[a]

| REGION | RESIDENTIAL | COMMERCIAL | INDUSTRIAL |
|---|---|---|---|
| New England | 88.2 | 56.1 | 95.7 |
| Middle Atlantic | 14.5 | 38.9 | 55.1 |
| East north central | 52.9 | 36.2 | 57.1 |
| West north central | 41.9 | 33.6 | 47.8 |
| South Atlantic | 78.7 | 58.7 | 06.6 |
| East south central | 78.0 | 40.0 | 89.1 |
| West south central | 30.1 | 21.5 | 42.9 |
| Mountain | 39.0 | 41.3 | 58.2 |
| Pacific | 78.3 | 65.5 | 90.9 |
| Noncontiguous | 63.2 | 51.8 | 70.0 |
| U.S. Average | 72.3 | 63.8 | 89.6 |

[a] Federal Power Commission, Typical Electrical Bills, 1975.

section below, the earnings record of the industry will be examined. The succeeding section will examine external financing problems for the industry.

### 2.3.1 Earnings and Internal Cash Flows

The electric utility has shown fair earnings growth in the 1970's, but this earnings growth has provided only a constant fraction of the funds needed for capital expenditures. The recent earnings history for investor-owned utilities is shown in Table 2-13 along with statistics of annual cash flows and capital expenditures. The net income for the utilities grew at a rate of 12.6 percent per annum for the period 1972 to 1976. Earnings growth was lowest in 1974, when a 6 percent increase was achieved, but recovered in 1975 to a healthy 16.6 percent. During the same period, capital expenditures for investor-owned utilities rose only 6 percent per year. However, a number of factors prevented utilities from increasing their ability to internally finance investments.

In order to examine cash flow, it is necessary to move from net income to retained cash income, i.e., that amount of earnings which is available for reinvestment. The utility net income figures include an allowance for funds used during construction (AFUDC). The AFUDC account does not represent cash earnings. It is, rather, an accounting technique which allows utilities to claim as earnings some of the implicit value of plants being constructed. In other words, it represents future earnings counted in the current period. The AFUDC portion of income, and thus the non-cash portion of income, has risen significantly. As can be derived from the table, AFUDC accounted for 9 percent of earnings in 1968, but 27 percent in 1976.

## TABLE 2-13

## NET INTERNAL CASH FLOWS FOR INVESTOR UTILITIES ($MM)[a]

| | 1976 | 1975 | 1974 | 1973 | 1972 | 1968 |
|---|---|---|---|---|---|---|
| Net income | 6,990 | 6,002 | 5,146 | 4,851 | 4,356 | 2,960 |
| Less AFUDC | 1,896 | 1,694 | 1,596 | 1,297 | 1,095 | 275 |
| Less dividend payouts | 5,118 | 4,415 | 3,818 | 3,424 | 3,037 | 2,117 |
| Retained cash income | 24 | (107) | (268) | 130 | (224) | 568 |
| Deferred income taxes | 2,426 | 1,576 | 1,002 | 718 | 534 | 163 |
| Depreciation and amortization | 4,563 | 4,117 | 3,638 | 3,270 | 2,920 | 2,044 |
| Internal cash flows | 7,013 | 5,586 | 4,372 | 4,118 | 3,230 | 2,775 |
| Capital expenditures | 17,027 | 15,130 | 16,421 | 14,979 | 13,345 | 7,169 |

---

[a] Edison Electric Institute, *Statistical Year Book of the Electric Utility Industry for 1976*. Capital expenditure figures are taken from "1978 Annual Statistical Issue," *Electrical World*.

Dividend payouts have risen with earnings through the 1970's. The payout of cash income, of course, reduced the amount of income left for reinvestment. When dividend payouts and AFUDC are subtracted from earnings, it is clear that little or no cash income is available for reinvestment. In 1968, retained cash income accounted for a significant if not large portion of annual capital expenditures, namely 8 percent.

The gap between retained cash income and capital expenditures must be made up by other internal cash flows and, as will be discussed later, external financing. The sources of cash flows for utilities are depreciation and amortization expenses and deferred income taxes. Both of these accounts are charged as operating expenses, but because they do not involve cash outlays, they represent retained funds. Depreciation is the larger of these two accounts, measured in 1976 at 4.5 billion for investor-owned utilities. Deferred income taxes have grown more rapidly, increasing from $163 million in 1968 to $2.4 billion in 1976. The deferred taxes may be thought of as an interest-free loan from the federal government. These two entries combined supplied $7 billion of the $17 billion needed for capital expenditures in 1976.

For rate-setting purposes, the productive life of generating plants is set at 30 to 40 years. The allowable depreciation in a given year is therefore 3 percent or less of the cost of existing plants. However, the costs of new plants are much greater than those of existing plants so the depreciation fund is not sufficient for new construction. The result is a need for increased financing in external capital markets.

To summarize, retained cash earnings have provided very little of the funds needed for reinvestment. Depreciation funds and deferred income taxes have been steadily growing, but supply only about 30 to 40 percent of the funds needed. The industry therefore looks to external capital markets for the bulk of its funds.

### 2.3.2 External Financing

The increased movement to external financing coincided with the decline in the rate of return for utilities. As a result, utility stocks and bonds declined in attractiveness to investors. The problem is accentuated because the capital requirements for the industry are extremely large. The relationship of utility financing to total new market issues of stocks and bonds is shown in Table 2-14. In each financing category (long-term debt, preferred and common stock), the percent of utility financing relative to the national average has increased greatly. The specific problems of the industry in each financing category are described below.

The volume of debt interest charges for the industry rose from less than $1 billion in 1965 to $5.6 billion in 1976. The rise in interest costs was due to the volume of debt financing, the rise in interest rates during the period, and the effect of the lowered rate of return on utility bond ratings. The investor's services companies, such as Standard & Poor's and Moody's which rate bond issues, normally look closely at a firm's interest coverage ratio, that is, the ratio of net income (before taxes and income) to annual interest charges. The ratio fell sharply for utilities in this period causing a decline in the risk

TABLE 2-14

ELECTRIC UTILITY INDUSTRY INCREMENTAL LONG-TERM FINANCING AS PERCENT OF TOTAL FOR ALL U.S. INDUSTRIES, 1965 to 1976 (%)[a]

| YEAR | LONG-TERM DEBT | PREFERRED STOCK | COMMON STOCK |
|---|---|---|---|
| 1965 | 10 | 29 | 7 |
| 1966 | 15 | 44 | 8 |
| 1967 | 12 | 51 | 9 |
| 1968 | 18 | 72 | 8 |
| 1969 | 20 | 56 | 10 |
| 1970 | 20 | 83 | 19 |
| 1971 | 17 | 50 | 22 |
| 1972 | 15 | 75 | 24 |
| 1973 | 23 | 55 | 33 |
| 1974 | 27 | 77 | 51 |
| 1975 | 18 | 46 | 51 |
| 1976 | 16 | 57 | 46 |

[a] Teknekron, Inc., Review of New Source Performance Standards for Coal-Fired Utility Boilers, Volume II Economic and Financial Impacts, p. A-20.

rating (toward more risk) for utility bonds. Since bonds which have a greater chance of defaulting must pay higher yields, debt financing costs increased.

Utility stock prices for the period performed poorly, although dividends were generally increased. The price/earnings ratio for utility stocks, which can be roughly interpreted as the premium placed by the market on a given stock, fell steadily from 19.8 in 1965 to 11.5 in 1970 and to 6.4 in 1976.[5] The decline in the ratio was caused largely by a fall in stock prices, and not by the gradual increase in earnings. The price fall meant an increase in the number of new shares which needed to be sold in order to obtain a given amount of capital.

Preferred stocks are also rated by investor services in terms of the firm's ability to meet scheduled dividend payout. The amount of preferred stock sold rose much more rapidly than income, leading to a decrease in the dividend coverage ratio. Preferred stock ratings fell, requiring an increase in stock yields.

## 2.4 Model Plant Descriptors

For all of the other industries covered in this study, model plants (or firms) were developed as a means of estimating the regulatory impacts on plant net income. For this industry model plants will be developed only as a means of estimating average waste quantities, and as a basis for cost estimates. The model plants are described in the next chapter. A complete analysis was not made of net income effects, due to the regulated nature of the industry. Eventual impacts are largely a function of the regulatory commission's attitude toward the additional expenditures. A qualitative discussion of RCRA impacts on utility net income and finances is provided in Chapter Four.

## NOTES TO CHAPTER TWO

1. Edison Electric Institute, Annual Electric Power Survey, April 1977, p. 16.

2. Edison Electric Institute, "Advance Release of Data for the Statistical Year Book of the Electric Utility Industry-Year 1977."

3. Teknekron, Inc., Review of New Source Performance Standards for Coal-Fired Utility Boilers, Volume II - Economic and Financial Impacts, p. 2-22.

4. Teknekron, Inc., p. 2-7.

5. Teknekron, Inc., p. A-22.

## CHAPTER THREE

# SOLID WASTE GENERATION IN THE ELECTRIC UTILITY INDUSTRY

The principal solid waste disposal issue for electric utilities is the potential environmental problems associated with the disposal of coal ash and FGD scrubber sludge. In this chapter, the physical and chemical properties of these wastes will be examined. Potential environmental problems, especially the toxicity of fly ash (as defined in the RCRA program), will be examined. The characteristics of oil ash will also be covered.

The disposal requirements for electric utility wastes are, of course, dependent on whether the wastes are to be considered hazardous under the RCRA. The issue is a complex one which cannot be readily decided based on available data. Cost estimates for disposal as a hazardous waste are provided below. Actual disposal costs will be highly region specific. In developing the cost estimates it was necessary to make a number of assumptions about a representative disposal operation. Details of the cost estimation are included in Section 3.10 and Appendix A. Also the administrative costs of RCRA compliance are covered at the end of this chapter.

## 3.1. Waste Characteristics

### 3.1.1 Coal Ash

The residual ash which results from the combustion of coal is primarily derived from the inorganic mineral matter in the coal. The amount of the residual is directly related to ash content of the coal, which can vary widely depending upon the circumstances in which the coal deposit was formed. The range of observed ash contents among the major types of coal is given below in Table 3-1. In each case the possible range is very large. On the average, eastern coals have a higher ash content than western coals. However, most eastern coal (bituminous coal) has a higher heat value than the subbituminous coal and lignite found in the west.

TABLE 3-1
RANGE OF ASH CONTENT IN COAL

| TYPE OF COAL | ASH (%) |
|---|---|
| Anthracite | 4-19 |
| Bituminous | 3-32 |
| Subbituminous | 3-16 |
| Lignite | 4-19 |

Therefore, the difference in ash generation rates is less than the difference between ash contents.

The ash residual is divided into fly ash and bottom ash or boiler slag. Fly ash is that part of the ash which is entrained in the combustion gas leaving the boiler. It is collected downstream with mechanical collectors and/or electrostatic precipitators or in flue gas desulfurization systems. The bottom ash is created from fused particles which are sufficiently heavy to drop out of the furnace gas stream. These particles are collected in the bottom of the furnace. Boilers are characterized in terms of their ash-handling equipment as being either wet-bottom or dry-bottom. The former require high temperatures in order to cause ash to soften and form slag (thus, wet-bottom), while the latter handle bottom ash as a solid material or as cinders.

The division of the ash residual is significant in that potentially hazardous ash constitutents may be found in varying amounts in either component.

### 3.1.1.1 Physical Properties of Ash

The fly ash and bottom ash are removed separately from the power plant although they are generally combined for ultimate disposal. In this section, the characteristics of the ash are discussed.

Fly ash consists largely of small glassy spheroids which are largely siliceous. The spherical particulates range in diameter from 0.5 to 100 microns.[1] The fly ash spans a color range of light tan to gray and to black. The darker colors are evident in ash with an increased carbon content. The lighter, tan-colored ash indicates high iron content. The pH of the fly ash is generally that of a mild or strong base, that is, a pH of 8 to 12.[2] Fly ash is a natural pozzolan, a pozzolan being a siliceous material that has little or no cementitious value itself, but in finely divided form and in the presence of moisture is able to chemically react with alkaline earth hydroxides to form a cementitious compound.

A portion of the fly ash produced consists of cenopheres. These are silicate glass spheres filled with nitrogen and carbon dioxide which vary from 20 to 200 microns in diameter. These particles may comprise as much as 5 percent by weight or 20 percent by volume of the fly ash.[3] These particles float on ash pond surfaces.

Bottom ash is formed as either solid materials or cinders (in dry-bottom boilers) or slag (in wet-bottom boilers). In the first case, a gray or black material in angular shaped particles is formed. The dry-bottom boiler ash has porous, dull reflective surfaces. Boiler slag consists of angular black particles with a smoother, glossy appearance. Bottom ash particles are larger than fly ash particles. Samples of bottom ash from a dry-bottom boiler have been measured to be 0.7 mm to 40 mm in diameter.[4]

#### 3.1.1.2 Chemical Constituents

The inorganic constituents of ash are the same as those typically found in rocks and soil. The major compounds are oxides of silicon, aluminum, iron, and calcium. These compounds comprise over 90 percent of the composition of ash. The exact proportions of each for six coal samples are presented in Table 3-2. The proportions of these chemicals appear fairly consistent for the six samples for which data are provided. However, widely divergent chemical makeups are possible for different coals. For example, the percent of silicon oxide in bituminous coal can vary from 5 to 70 percent.[5]

## TABLE 3-2

## COMPARISON OF FLY ASH AND BOTTOM ASH FROM VARIOUS UTILITY PLANTS (%)[a]

| ELEMENT OR COMPOUND | PLANT 1 | | PLANT 2 | | PLANT 3 | | PLANT 4 | | PLANT 5 | | PLANT 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FA | BA | FA | BA | FA | BA | FA | BA | FA | BA | FA | BA |
| $SiO_2$ | 59.0 | 58.0 | 57.0 | 59.0 | 43.0 | 50.0 | 54.0 | 59.0 | NR | NR | 42.0 | 49.0 |
| $Al_2O_3$ | 27.0 | 25.0 | 20.0 | 18.5 | 21.0 | 17.0 | 28.0 | 24.0 | NR | NR | 17.0 | 19.0 |
| $Fe_2O_3$ | 3.8 | 4.0 | 5.8 | 9.0 | 5.6 | 5.5 | 3.4 | 3.3 | 20.4 | 30.4 | 17.3 | 16.0 |
| CaO | 3.8 | 4.3 | 5.7 | 4.8 | 17.0 | 13.0 | 3.7 | 3.5 | 3.2 | 4.9 | 3.5 | 6.4 |
| $SO_3$ | 0.4 | 0.3 | 0.8 | 0.3 | 1.7 | 0.5 | 0.4 | 0.1 | NR | 0.4 | NR | NR |
| MgO | 0.96 | 0.88 | 1.15 | 0.92 | 2.23 | 1.61 | 1.29 | 1.17 | NR | NR | 1.76 | 2.06 |
| $Na_2O$ | 1.88 | 1.77 | 1.61 | 1.01 | 1.44 | 0.64 | 0.38 | 0.43 | NR | NR | 1.36 | 0.67 |
| $K_2O$ | 0.9 | 0.8 | 1.1 | 1.0 | 0.4 | 0.5 | 1.5 | 1.5 | NR | NR | 2.4 | 1.9 |
| $P_2O_5$ | 0.13 | 0.06 | 0.04 | 0.05 | 0.7 | 0.3 | 1.0 | 0.75 | NR | NR | NR | NR |
| $T_iO_2$ | 0.43 | 0.62 | 1.17 | 0.67 | 1.17 | 0.5 | 0.83 | 0.5 | NR | NR | 1.0 | 0.68 |

---

[a] Ray, S.S. and F.G. Parker, Characterization of Ash From Coal-Fired Power Plants, Tennessee Valley Authority, January 1977, p. 46. Data were derived by TVA from a number of previous studies.

The distribution of these elements is evenly spread between fly ash and bottom ash. For none of the six samples are there order of magnitude differences in the amount of a given chemical found in the fly ash and bottom ash portions.

### 3.1.1.3 Trace Element Contents

The trace elements found in coal ash and the average amounts of each are displayed in Table 3-3. A number of these and other substances are referenced in the U.S. EPA Safe Drinking Water Standards as being potentially toxic if they migrate to water sources. As can be seen from the table, the concentrations of elements vary widely among elements and among coal types. Within coal types there can be large variations due to the specific mineralogy and genesis of a specific coal vein. In general, the concentrations of the trace metals are high and exhibit a wide variance. Leachate quality is dependent upon the solubility of the metals in ponds; the solubility issue is discussed in a later section.

The distribution of trace elements among types of ash is an important consideration because there is the possibility that the different ashes could be disposed of separately. In general, the distribution of elements between fly ash and bottom ash depends on a variety of factors, many of which are highly variable. The type of coal used and characteristics of the individual combustion process are most important. A comparison of the trace element content for ashes at six utility plants is shown in Table 3-4. The elements tested for at the six plants are roughly but not exactly the same as those for which information is shown in Table 3-3.

## TABLE 3-3

## AVERAGE AMOUNTS OF TRACE ELEMENTS IN COAL ASHES (ppm)[a]

| ELEMENT | ANTHRACITES | HIGH-VOLATILE BITUMINOUS | MEDIUM-VOLATILE BITUMINOUS | LOW-VOLATILE BITUMINOUS | LIGNITES AND SUB-BITUMINOUS |
|---|---|---|---|---|---|
| Ag | 1[b] | 3[b] | 1.4[b] | 1[b] | 50[b] |
| B | 90 | 770 | 218 | 123 | 1,020 |
| Ba | 866 | 1,253 | 896 | 740 | 5,027 |
| Be | 9 | 17 | 13 | 16 | 6 |
| Co | 81 | 64 | 105 | 172 | 45 |
| Cr | 304 | 193 | 169 | 221 | 54 |
| Cu | 405 | 293 | 313 | 379 | 655 |
| Ga | 42 | 40 | 52[b] | 41 | 23 |
| Ge | 20[b] | 285[b] | 20[b] | 20[b] | 100[b] |
| La | 142 | 111 | 83 | 110 | 62 |
| Mn | 270 | 170 | 1,432 | 280 | 688 |
| Ni | 220 | 154 | 263 | 141 | 129 |
| Pb | 81 | 183 | 96 | 89 | 60 |
| Sc | 61 | 32 | 56 | 50 | 18 |
| Sn | 962 | 171 | 75 | 92 | 156 |
| Sr | 177 | 1,987 | 668 | 818 | 4,660 |
| V | 248 | 249 | 390 | 278 | 125 |
| Y | 106 | 102 | 151 | 152 | 51 |
| Yb | 8 | 10 | 9 | 10 | 4 |
| Zn | 350[b] | 310 | 195 | 231 | 320[b] |
| Zr | 688 | 411 | 326 | 458 | 245 |

---

[a] O'Gorman, J.V. and P.L. Walker, Jr., *Mineral Matter and Trace Elements in U.S. Coals*, Department of Interior, July 1972.

[b] Insufficient data to compute an average value; maximum value is shown in table.

## TABLE 3-4

## COMPARISON OF FLY ASH AND BOTTOM ASH FROM VARIOUS UTILITY PLANTS (ppm)[a]

| ELEMENT OR COMPOUND | PLANT 1 | | PLANT 2 | | PLANT 3 | | PLANT 4 | | PLANT 5 | | PLANT 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FA | BA | FA | BA | FA | BA | FA | BA | FA | BA | FA | BA |
| As | 12.0 | 1.0 | 8.0 | 1.0 | 15.0 | 3.0 | 6.0 | 2.0 | 8.4 | 5.8 | 110.0 | 18.0 |
| Be | 4.3 | 3.0 | 7.0 | 7.0 | 3.0 | 2.0 | 7.0 | 5.0 | 8.0 | 7.3 | NR | NR |
| Cd | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1.0 | 1.0 | 6.44 | 1.08 | 8.0 | 1.1 |
| Cr | 20.0 | 15.0 | 50.0 | 30.0 | 150.0 | 70.0 | 30.0 | 30.0 | 206.0 | 124.0 | 300.0 | 152.0 |
| Cu | 54.0 | 37.0 | 128.0 | 48.0 | 69.0 | 33.0 | 75.0 | 40.0 | 68.0 | 48.0 | 140.0 | 20.0 |
| Hg | 0.07 | 0.01 | 0.01 | 0.01 | 0.03 | 0.01 | 0.08 | 0.01 | 20.0 | 0.51 | 0.05 | 0.028 |
| Mn | 267.0 | 366.0 | 150.0 | 700.0 | 150.0 | 150.0 | 100.0 | 100.0 | 249.0 | 229.0 | 298.0 | 295.0 |
| Ni | 10.0 | 10.0 | 50.0 | 22.0 | 70.0 | 15.0 | 20.0 | 10.0 | 134.0 | 62.0 | 207.0 | 85.0 |
| Pb | 70.0 | 27.0 | 30.0 | 30.0 | 30.0 | 20.0 | 70.0 | 30.0 | 32.0 | 8.1 | 80.0 | 6.2 |
| Se | 6.9 | 0.2 | 7.9 | 0.7 | 18.0 | 1.0 | 12.0 | 1.0 | 26.5 | 5.6 | 25.0 | 0.08 |
| V | 90.0 | 70.0 | 150.0 | 85.0 | 150.0 | 70.0 | 100.0 | 70.0 | 341.0 | 353.0 | 440.0 | 260.0 |
| Zn | 63.0 | 24.0 | 50.0 | 30.0 | 71.0 | 27.0 | 103.0 | 45.0 | 352.0 | 150.0 | 740.0 | 100.0 |
| B | 266.0 | 143.0 | 200.0 | 125.0 | 300.0 | 70.0 | 700.0 | 300.0 | NR | NR | NR | NR |
| Co | 7.0 | 7.0 | 20.0 | 12.0 | 15.0 | 7.0 | 15.0 | 7.0 | 6.0 | 3.6 | 39.0 | 20.8 |
| F | 140.0 | 50.0 | 100.0 | 50.0 | 610.0 | 100.0 | 250.0 | 85.0 | 624.0 | 10.6 | NR | NR |

---

[a] Ray, S.S. and F.G. Parker, Characterization of Ash From Coal-Fired Power Plants, Tennessee Valley Authority, January 1977, p. 46. Data were derived by TVA from a number of studies.

The partitioning of trace elements between fly ash and bottom ash varies significantly depending on the trace element examined. The distribution of some elements, such as cadmium, beryllium, and cobalt, is similar between ashes. Some of these elements tend to occur more frequently in fly ash, but the difference is considerably less than an order of magnitude. Several elements are mainly evident in fly ash. Arsenic, chromium, copper, selenium, zinc, boron, and fluorine all show higher concentrations in fly ash. The fly ash concentrations among these elements range from 2 to 20 times the concentration in bottom ash.

Conclusions about the partitioning of specific elements are limited by variability among plants. For example, the manganese data show both a perfectly even distribution (Plant 3) and a high concentration of the element only in bottom ash (Plant 2). In general, the results are similar, both in the rough level of elements and in the occasional order-of-magnitude variation in levels among samples.

Overall, the fly ash component tends to show greater trace element concentrations. However, because bottom ash includes the same elements and because of the wide range of possible trace element concentrations, the potential toxicity of the bottom ash needs also to be considered.

### 3.1.2 Sludge from Flue-Gas-Desulfurization Systems

A number of electric utilities have been fitted with flue-gas-desulfurization systems for the control of air emissions. The inception of New Source Performance Standards for coal-fired utility boilers will result in a rapid increase in the percentage of utility boilers which are fitted with these systems. A major concern with these systems is the disposal or reuse of the FGD system byproducts. In this section, the characteristics of scrubber sludge wastes will be examined. The analysis will focus on lime or limestone scrubbing systems which are "throw-away" systems in which a waste stream is produced. Regenerable FGD systems have not been used in many cases and will not be discussed here.

The use of throw-away flue-gas-desulfurization systems or scrubbers usually results in a waste stream of a thin water slurry of from 5 to 15 percent solids. Sulfur dioxide gas in the air flow is contacted with the system reagent, lime ($CaO$), or limestone ($CaCO_3$), and the resulting solid mixture includes calcium hydroxide, calcium carbonate, calcium sulfate, and calcium sulfite.[7] Fly ash may also be removed by the FGD system and removed simultaneously with the scrubber bleed stream, although the properties of sludge without fly ash will be considered here.

### 3.1.2.1 Physical Properties

Water is used as the medium in which the necessary chemical reactions take place and the water content of the sludge waste stream largely determines the physical properties of the sludge. An increase in water content is undesirable for a number of reasons. It increases the volume and weight of the material which must be disposed of. It also reduces the extent to which the sludge can be compacted and, by lowering the shear strength of the material, reduces the bearing capacity of any given disposal area. Finally, it increases the permeability and thus the quantity of leachate produced by the sludge. The primary benefit of the water content is that it facilitates transporting of sludge (by pumping) from the FGD system to the disposal area.

The amount of water held is directly affected by the proportions of calcium sulfite and calcium sulfate in the sludge. The ease and extent of possible dewatering is also affected by the ratio of these constituents. In general, limestone scrubbers produce sludges with a predominance of sulfite. The larger sulfite concentration is attributed to the lower pH at which these scrubbers operate. Lime scrubber sludge is more variable but some sulfate is generally present. Calcium sulfite may constitute anywhere from 20 to 90 percent of the sulfur-containing solids. The proportion of sulfite must fall below 20 percent (80 percent sulfate) before the material may be readily dewatered.[8]

The proportion of sulfite and sulfate is determined by a number of factors including the choice of reagent already mentioned (lime or limestone). The other factors are (1) the amount of excess air in the boiler and (2) the pH maintained in the scrubber system. Much excess air allows for oxidation of the sulfite to sulfate, thereby improving the handling qualities of the sludge. Conversely, the systems which maintain a lower pH value (which are also typically limestone systems) have a higher volume of sulfite.[9]

The effect of oxidation on scrubber sludge properties has been widely noted. Some scrubber manufacturers are including forced oxidation with their system in order to convert the calcium sulfite to calcium sulfate.[10]

### 3.1.2.2 Chemical Characteristics of FGD Sludge

The chemical pollutants in FGD scrubber sludge will be dominated by the characteristics of the coal burned if fly ash is collected with the scrubbing operation. However, it is appropriate to consider FGD sludge separately since in some cases the two waste streams are produced separately and could be handled separately. As will be discussed, the amount of trace elements originating from non-coal sources, such as the scrubber reagent, are small compared to those from the coal ash.

### 3.1.2.3 Phase Composition and Trace Elements

The primary constituents of FGD waste solids are calcium sulfite ($CaSO_3$), calcium sulfate, calcium carbonate, and magnesium sulfate. Samples of the wastes from a number of plants are shown in Table 3-5. (The samples shown generally included some fly ash.) In each case the source of the sample and the reagent used is identified. The bulk of the calcium sulfate is in dihydrate form ($CaSO_4 \cdot 2H_2O$) which is gypsum, but some is in the hemihydrate form ($CaSO_4 \cdot 1/2H_2O$). The calcium sulfite appears as a hemihydrate ($CaSO_3 \cdot 1/2H_2O$). The calcium carbonate ($CaCO_3$) found in the samples results from excess reagent in the scrubber system, whether lime or limestone is used.

The reaction products described above cover the great bulk of the material in scrubber solids. Remaining constituents are trace elements derived from any fly ash included, from the plant makeup waters used in sluice and slurry systems, and from the lime or limestone reagents. The trace element concentrations in fly ash are significant, as described previously. In contrast, the trace elements in plant makeup water are extremely small.[12] The elements in the reagents have a moderate effect on the total trace elements in the system. The concentration levels for the latter, as measured at five plants, are shown in Table 3-6.

TABLE 3-5

PHASE COMPOSITION OF FGD WASTE SOLIDS (wt. %)[a]

| FORMULA | TVA SHAWNEE LIME-STONE 2/1/73 | TVA SHAWNEE LIME-STONE 7/12/73 | TVA SHAWNEE LIME-STONE 6/15/74 | TVA SHAWNEE LIME-STONE 3/19/74 | SCE MOHAVE LIME-STONE 3/30/73 | GM PARMA DOUBLE ALKALI 7/17/74 | APS CHOLLA LIME-STONE 4/1/74 | DLC PHILLIPS LIME 6/17/74 |
|---|---|---|---|---|---|---|---|---|
| $CaSO_4 \cdot 2H_2O$ | 21.9 | 15.4 | 31.2 | 6.3 | 84.6 | 48.3 | 17.3 | 19.0 |
| $CaSO_3 \cdot 1/2H_2O$ | 18.5 | 21.4 | 21.8 | 48.8 | 8.0 | 12.9 | 10.8 | 12.9 |
| $CaSO_4 \cdot 1/2H_2O$ | - | - | - | - | - | 19.2 | - | - |
| $CaCO_3$ | 38.7 | 20.2 | 4.5 | 2.5 | 6.3 | 7.7 | 2.5 | 0.2 |
| $MgSO_4 \cdot 6H_2O$ | 4.6 | 3.7 | 1.9 | 1.9 | - | - | - | - |
| Fly ash | 20.1 | 40.9 | 40.1 | 40.5 | 3.0 | 7.4 | 58.7 | 59.7 |

---

[a] Leo, P.P. and J. Rossoff, Control of Waste and Water Pollution from Power Plant Flue Gas Cleaning Systems: First R&D Report, EPA-600/7-76-018 (October 1976), as cited in EPRI Report FP-671.

## TABLE 3-6

## TRACE ELEMENT ANALYSES OF LIME AND LIMESTONE SAMPLES (ppm)[a,b]

| ELEMENTS | STATION NUMBER | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Sb | 5.3 | 3.1 | <0.80 | 1.3 | 3.2 |
| As | 3.0 | 2.9 | 0.83 | 0.66 | 2.7 |
| Ba | <30.0 | <30.0 | <30.0 | <30.0 | <30.0 |
| Be | 3.0 | 0.14 | <0.27 | 0.37 | 0.17 |
| B | 6.45 | 45.1 | 11.2 | 10.8 | 17.4 |
| Cd | 0.28 | 0.24 | 0.92 | 0.90 | 0.65 |
| Cr | 1.2 | 3.5 | 0.61 | 0.57 | <0.80 |
| F | 105.0 | 134.0 | 307.0 | 103.0 | 117.0 |
| Ge | <1.0 | <0.1 | <0.1 | <0.1 | <0.11 |
| Hg | <0.01 | 0.012 | <0.01 | <0.01 | 0.02 |
| Pb | 1.3 | 10.0 | 26.0 | 14.0 | 13.0 |
| Mn | 29.8 | 83.5 | 43.6 | 20.3 | 290.0 |
| Mo | 150.0 | 0.04 | 15.0 | 8.9 | 12.0 |
| Ni | 4.3 | 4.62 | <12.0 | <6.0 | 6.2 |
| Se | 0.08 | 0.17 | 0.086 | 0.3 | 0.22 |
| V | <50.0 | <24.0 | <160.0 | <24.0 | 160.0 |
| Zn | 9.6 | | 71.4 | 28.0 | 48.0 |
| Cu | 5.8 | 14.0 | 9.3 | 15.6 | 2.4 |

---

[a] Holland, W.F., et al., The Environmental Effects of Trace Elements in the Pond Disposal of Ash and FGD Sludge, EPRI RP 202, September 1975.

[b] All results are reported as the average of duplicate analyses. Analyses are in ppm on a dry sample basis. Original source does not report which samples are lime or limestone.

Lime or limestone elemental concentrations appear to be fairly consistent across the samples examined and are quite small. In exceptional cases, the lime or limestone reagent could cause the presence of high metal concentrations.

A variety of tests have been run to determine the overall chemical analysis of FGD scrubber sludge.[13] The results of two such tests to determine the solids makeup of sludges are provided in Table 3-7. Total trace concentrations are considerable, as is immediately evident. Barium and fluorine are particularly high in the two samples. Concentrations for the other elements are more moderate but not negligible. For neither of the plants is fly ash included in the sludge. A portion of the element concentration did result from the lime or limestone inputs.[14]

## 3.2 Leachate and Solubility Analyses

The important consideration for the quality of leachate produced by utility disposal areas is the solubility of trace metal components in the ash and sludge. Use will be made of the results of leachate tests reported from various sources. As will be shown, the tests examined show some potential problem of toxicity for ash and sludge ponds. An additional section is also provided to briefly discuss some analyses of the mutagenicity of fly ash.

### 3.2.1 Solubility Analyses

Solubility of the trace metals appears to be fairly low for both ash and sludge leachate. However, tests run on ash and sludge leachate indicate that the toxicity standards of RCRA (Options A and B) may be violated in a number of cases.

## TABLE 3-7

## TRACE ELEMENT ANALYSES OF LIME/LIMESTONE SLUDGE SOLIDS (ppm)[a]

| ELEMENT | STATION NUMBER 1 | 2 |
|---|---|---|
| Sb | 4.3 | 7.5 |
| As | 4.0 | 12.0 |
| Ba | 500.0 | 4,400.0 |
| Be | 1.5 | 2.0 |
| B | 68.7 | 211.0 |
| Cd | 0.4 | 1.1 |
| Cr | 1.6 | 4.0 |
| F | 1,017.0 | 950.0 |
| Ge | <1.0 | 2.4 |
| Hg | <0.01 | 0.46 |
| Pb | 1.6 | 2.4 |
| Mn | 56.0 | 147.0 |
| Mo | 81.0 | 8.0 |
| Ni | 13.0 | 26.0 |
| Se | 4.13 | 3.8 |
| V | <50.0 | <100.0 |
| Zn | 13.9 | 169.0 |
| Cu | 38.9 | 104.0 |

[a] Holland, W.F., et al., The Environmental Effects of Trace Elements in the Pond Disposal of Ash and FGD Sludge, EPRI RP 202, September 1975.

Table 3-8 presents the results of coal ash leachate tests vis-a-vis the RCRA limitations on trace metal content. The tests presented are derived from a study by Radian Corporation of the environmental effects of disposal at five power plants.[15] The concentration of those elements for which an RCRA standard is explicit is generally acceptable. Elements which show unacceptable levels in at least one case are barium (Station 1), chromium (Station 4), and selenium (Station 4).

Another analysis of trace element solubility in ash ponds was performed at a coal-fired plant in Fruitland, New Mexico.[16] As shown in Table 3-9, solubility tests were formed with a variety of solutions of varying acidity. In general, trace element solubility is inversely related to the pH of the extractant. The high molarity solutions mobilized large amounts of metals. With weaker acid solutions and with water, the trace element concentrations are closer to the RCRA standards of 10 times the Safe Drinking Water Standards. One element which nevertheless exceeded the RCRA limits is selenium.

In actual practice, no fly ash samples have been found to fail the Extraction Procedure defined for Option B, but only a small sample of ash has been tested. In a study of coal ash characteristics made by Energy Resources Co. (The Toxicity and Radioactivity of Ashes from U.S. Coals) it was estimated that 28 percent of coal ash was likely to have hazardous characteristics due to trace metal leaching. The estimate was based on an analysis of trace elements in U.S. coals and the likely leachate tendencies in coal ash. For the purposes of this study, all coal ash will be assumed to be hazardous. This assumption is made to bound the "worst-case" economic impacts.

## TABLE 3-8

## EQUILIBRIUM CONCENTRATIONS OF TRACE ELEMENTS IN COAL ASH LEACHATE[a,b]

| | STATION NUMBER | | | | | RCRA LIMI-TATION | LIMITS EX-CEEDED |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| Bottom ash (%) | 20 | 20 | 20 | 50 | 100 | | |
| Fly ash (%) | 80 | 80 | 80 | 50 | 0 | | |
| pH | 12.5 | 9.5 | 12.2 | 12.0 | 8.2 | | |
| Element (ppm) | | | | | | | |
| Antimony | 0.006 | 0.018 | 0.033 | 0.022 | 0.0087 | None | - |
| Arsenic | <0.002 | 0.084 | 0.015 | 0.072 | 0.006 | 0.5 | No |
| Barium | 40.0 | <0.3 | <0.3 | <0.3 | <0.3 | 10.0 | Yes |
| Beryllium | 0.003 | 0.00064 | 0.0007 | 0.001 | 0.00026 | None | - |
| Boron | 0.03 | 16.9 | 0.21 | 1.1 | 0.048 | None | - |
| Cadmium | <0.001 | 0.0025 | <0.01 | <0.001 | 0.0011 | 0.1 | No |
| Chromium | <0.001 | 0.21 | 0.11 | 1.0 | 0.014 | 0.5 | Yes |
| Fluorine | 2.3 | 1.4 | 2.0 | 17.3 | 1.4 | None | - |
| Germanium | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | None | - |
| Mercury | 0.0006 | 0.0005 | 0.015 | 0.0003 | 0.0003 | 0.02 | No |
| Lead | 0.0068 | 0.0027 | 0.024 | 0.0043 | 0.0063 | 0.5 | No |
| Manganese | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | None | - |
| Molybdenum | 0.047 | 0.052 | 0.05 | 0.69 | 0.010 | None | - |
| Nickel | <0.05 | 0.015 | 0.025 | <0.05 | 0.046 | None | - |
| Selenium | 0.009 | <0.0005 | 0.033 | 0.47 | <0.0005 | 0.1 | Yes |
| Vanadium | <0.1 | <0.1 | <0.1 | <0.2 | <0.1 | None | - |
| Zinc | 0.038 | 0.025 | 0.19 | <0.005 | 0.0175 | None | - |
| Copper | <0.005 | 0.031 | 0.092 | 0.013 | 0.015 | None | - |

[a] Radian Corporation, Environmental Effects of Trace Elements from Ponded Ash and Scrubber Sludge.

[b] These results do not reflect tests made using the Extraction Procedure proposed by EPA.

## TABLE 3-9

## PERCENTAGE OF TRACE ELEMENT CONTENT OF ASH EXTRACTED WITH VARYING ACIDIC SOLUTIONS[a]

| | EXTRACTANT | | | | | | | | CONCENTRATION IN PRECIPITATOR ASH (μg/g) |
|---|---|---|---|---|---|---|---|---|---|
| | $HNO_3$ | HCl | CITRIC ACID | $HNO_3$ | $HNO_3$ | $HNO_3$ | $H_2O$ | $NH_4OH$ | |
| Molarity (M) | 1.0 | 1.0 | 0.1 | 0.1 | 0.01 | 0.001 | | 0.1 | |
| Initial pH | 0.5 | 0.5 | 2.2 | 1.4 | 2.2 | 3.1 | 11.3 | 11.3 | |
| Final pH | 0.5 | 0.6 | 3.6 | 4.1 | 11.7 | 11.9 | 11.9 | 11.9 | |
| Element (%) | | | | | | | | | |
| As | 64 | 78 | 59 | 0.65 | 0.31 | 0.17 | 0.10 | 0.51 | 12 |
| B | 78 | 24 | 94 | 55 | 3.9 | 1.4 | 1.5 | <0.05 | 260 |
| Be | 8.6 | 12 | 6.1 | 1.7 | <0.09 | <0.09 | <0.09 | <0.09 | 4.7 |
| Cd | 48 | 32 | 33 | 35 | 3.8 | 0.28 | <0.14 | 0.14 | 0.29 |
| Cr | 15 | 14 | 13 | 1.2 | 0.53 | 0.38 | 0.33 | 0.29 | 34 |
| Cu | 7.3 | 7.9 | 4.6 | 3.3 | 0.11 | <0.01 | <0.01 | <0.01 | 58 |
| F | 75 | 63 | 86 | 83 | 11 | 8.1 | 7.2 | 8.7 | 120 |
| Mo | 120 | 120 | 110 | 4.7 | 57 | 55 | 59 | 54 | 4.2 |
| Se | 78 | 35 | 46 | 5.1 | 11 | 5.9 | 5.1 | 4.5 | 8.0 |
| V | 20 | 28 | 16 | 0.04 | 0.02 | <0.01 | <0.01 | <0.01 | 98 |
| Zn | 3.1 | 3.1 | 1.8 | 1.2 | 0.27 | <0.03 | <0.03 | 0.07 | 160 |

---

[a] Dreesen, D.R., "Comparison of Levels of Trace Elements Extracted From Fly Ash and Levels Found in Effluent Waters From a Coal-Fired Plant," Environmental Science and Technology, October 1977.

A solubility analysis of scrubber sludge was also performed by Radian Corporation. The results of this study are presented in Table 3-10 for three stations and for an analysis of the lime input at one station. The trace element concentrations are low. Potential problems appear only for fluorine and a limitation for this element has not been specified in RCRA.[17] The lime input at Station 1 is shown to contribute a small portion of the trace amounts for most elements listed.

Other analyses of scrubber sludge show the possibility that scrubber sludge may exceed the RCRA limits in some cases. The range of elemental composition for scrubber sludge leachates, as drawn from several studies, is provided in Table 3-11. The maximum values exceed the 10X Safe Drinking Water Standards for boron, mercury, and selenium. Additional analyses of scrubber sludge may be found in the literature.[18] In some cases the results are skewed by the inclusion of fly ash with the scrubber sludge. The fly ash trace element concentration is greater than that for scrubber sludge and would increase the levels shown in a leachate test. As a general conclusion, scrubber sludge without fly ash will have a lower metals content in solution than fly ash ponds.

As a general conclusion, scrubber sludge will probably be classed as nonhazardous in most cases. It is also possible that scrubber sludge could be combined with hazardous fly ash to produce a nonhazardous mixture. However, in order to bound the possible economic impacts it will be assumed that scrubber sludge is a hazardous waste.

## TABLE 3-10

## EQUILIBRIUM CONCENTRATIONS OF TRACE ELEMENTS IN FGD SLUDGE LEACHATE[a]

| | STATION NUMBER | | | STATION 1 LIME | RCA LIMITATION |
|---|---|---|---|---|---|
| | 1 | 4 | 5 | | |
| pH | 8.5 | 9.7 | 8.4 | 12.6 | |
| Element (ppm) | | | | | |
| Antimony | 0.014 | 0.013 | 0.035 | 0.016 | None |
| Arsenic | <0.002 | <0.002 | 0.03 | <0.002 | 0.5 |
| Barium | 2.0 | <0.3 | <0.3 | <0.3 | 10.0 |
| Beryllium | 0.002 | 0.001 | 0.002 | 0.001 | None |
| Boron | 2.6 | 6.3 | 0.96 | 0.22 | None |
| Cadmium | 0.0005 | <0.001 | 0.002 | <0.001 | 0.1 |
| Chromium | 0.001 | 0.011 | <0.001 | 0.004 | 0.5 |
| Fluorine | 31.5 | 8.7 | 7.6 | 1.2 | None |
| Germanium | <0.01 | <0.01 | 0.02 | <0.01 | None |
| Mercury | 0.0005 | 0.001 | 0.0008 | 0.002 | 0.02 |
| Lead | 0.0056 | 0.0033 | 0.0061 | 0.0027 | 0.5 |
| Manganese | <0.002 | <0.002 | <0.002 | <0.002 | None |
| Molybdenum | 0.063 | 0.061 | 0.075 | 0.011 | None |
| Nickel | <0.05 | <0.05 | <0.05 | <0.05 | None |
| Selenium | 0.045 | <0.0096 | 0.016 | 0.0005 | 0.1 |
| Vanadium | <0.1 | <0.1 | <0.1 | <0.1 | None |
| Zinc | 0.005 | 0.052 | <0.005 | 0.11 | None |
| Copper | 0.031 | 0.045 | <0.005 | 0.013 | None |

---

[a] Holland, W.F., et al., The Environmental Effects of Trace Elements in the Pond Disposal of Ash and FGD Sludge, EPRI RP 202, September 1975.

## TABLE 3-11

## ELEMENTAL COMPOSITION OF SCRUBBER SLUDGE LEACHATE[a,b]

| ELEMENT | STANDARD | MAXIMUM (mg/l) | MINIMUM (mg/l) | STANDARD EXCEEDED 10X SDWA |
|---|---|---|---|---|
| As | 0.05 | 0.13<br>0.30 | 0.001<br>0.008 | No |
| Ba | 1.00 | 2.00 | 0.002 | No |
| B | 1.00<br>0.75/irr. | 40.00 | 0.220 | Yes |
| Cd | 0.01 | 0.047 | 0.005 | No |
| Cr | 0.05 | 0.011<br>0.250 | 0.001 | No |
| Cu | 1.00 | 0.56 | 0.002 | No |
| Pb | 0.010 | 0.04 | 0.003 | No |
| Hg | 0.002 | 0.07<br>0.003 | 0.0004 | Yes |
| Ni | 0.50/irr. | 0.05 | 0.015 | No |
| Se | 0.01 | 0.54 | 0.0005 | Yes |
| V | - | 0.20 | 0.100 | - |
| Zn | 5.00 | 4.20 | 0.010 | No |

[a] Fred C. Hart Associates, Inc., The Impact of RCRA (PL94-580) on Utility Solid Wastes, EPRI FP-878, August 1978.

[b] These results do not reflect tests made using the Extraction Procedure proposed by EPA.

## 3.3 Hazardous Waste Generation from Oil-Burning Power Plants

When oil instead of coal is burned by electric utilities small quantities of fly ash and bottom ash are produced. The amount of ash is less than 1 percent of that produced by equivalent coal-burning installations. However, the quantities produced will be sufficient to place many utilities into the generator category as defined by RCRA (see Section 3.5.1 below).

### 3.3.1 Chemical Makeup of Oil Fly Ash

Oil fly ash has higher metal concentrations than coal ash. The makeup of a sample of oil ash residual is shown in Table 3-12. High concentrations of various metals represent the entire mass of the ash sample. The sample includes nearly a 20 percent concentration of vanadium, a metal which is sufficiently valuable to encourage recovery. As a result, a number of utilities sell their oil ash.

In addition to the inorganic constituents shown in Table 3-12, organic material may represent 50 percent of the ash volume.[19] The amount of uncombusted material can be reduced by reinjecting the fly ash into the furnace. The ash residual can then be removed as bottom ash with insignificant amounts of organic material. Reinjection of ash also has the advantage of raising the vanadium content of the bottom ash and making it more attractive for recovery.

The higher metal content of oil ash raises the obvious question of metal content in any leachate produced. Little research has been published to date. In general it will be assumed that leachate from untreated oil fly ash will have a

## TABLE 3-12

## TYPICAL RESIDUAL OIL ASH ANALYSIS[a]

| CONSTITUENT | WEIGHT (%) |
|---|---|
| Iron | 22.99 |
| Aluminum | 21.90 |
| Vanadium | 19.60 |
| Silicon | 16.42 |
| Nickel | 11.86 |
| Magnesium | 1.78 |
| Chromium | 1.37 |
| Calcium | 1.14 |
| Sodium | 1.00 |
| Cobalt | 0.91 |
| Titanium | 0.55 |
| Molybdenum | 0.23 |
| Lead | 0.17 |
| Copper | 0.05 |
| Silver | 0.03 |
| Total | 100.00 |

---

[a] Danielson, J., Air Pollution Engineering Manual, U.S. Environmental Protection Agency, May 1973, as cited in Study of Electrostatic Precipitators Installed in Oil-Fired Boilers, Southern Research Institute study for EPRI, June 1978.

higher metal content than coal ash, and that it will fail RCRA standards for toxicity. This conclusion is based on the evidence of metal concentrations in oil fly ash.

## 3.4 Other Electric Utility Solid Waste Streams

Routine maintenance operations, in the form of the cleaning of boilers and other equipment, produce occasional waste flows. Additional waste is generated in the form of coal pile run-off. Waste streams must generally be treated prior to discharge and pollutants will therefore be captured in the resulting wastewater treatment sludges. These waste streams and their likely classification vis-a-vis RCRA will be covered in this section.

### 3.4.1 Metal Cleaning Wastes

A variety of maintenance operations is required to sustain efficient boiler operation. The wastewater streams generated consist of the cleaning solution used and the matter removed from boiler equipment. The latter is likely to consist of oil and grease and suspended solids. Specific sources of wastewater are (1) boiler cleaning, (2) boiler fireside cleaning, (3) air preheater cleaning, (4) feedwater heating cleaning, and a variety of other metal-cleaning operations.

Resulting wastewater treatment sludge would pick up the trace element concentrations of the effluent flows. Trace element concentrations are highly variable, but would generally exceed RCRA limitations based on information about concentrations in the effluent stream.[20]

### 3.4.2 Coal Pile Runoff

Coal-burning utilities reserve significant land areas for primary and reserve coal storage piles. One study puts the posssible range of the required land area at 25 to 100 acres. Depending on the height of the pile, from 780 to 2,340 square yards per megawatt of capacity would be required. Pile heights range from 25 to 40 feet.[21]

The environmental problems associated with coal-pile runoff are simiar to those for acid drainage from coal mines. The physical and chemical constituents of coal-pile runoff are shown in Table 3-13. An extremely wide range of variability exists for trace elements. This variability is not dissimilar to that for coal and coal ash. The pH of coal-pile runoff will also be low enough on occasion to fail RCRA standards.

If the coal pile runoff if collected, an NPDES permit is required for discharge. As a hazardous waste its collection would be required under RCRA. Thus, uncontrolled runoff would not be allowed. It will be presumed for this study that the collected runoff is disposed with other coal wastes. A separate estimate of control costs for the runoff (for leachate collection) was not made on the presumption that the same leachate collection and treatment system as for the disposal site could be used. If this assumption is not made, only a small increase (less than 2 percent) in total compliance costs would be incurred.

## TABLE 3-13

## CONSTITUENTS OF COAL-PILE RUNOFF[a]

| | RANGE (mg/l) |
|---|---|
| Conventional measures of pollution | |
| pH | 2.100 - 6.600 |
| Total suspended solids | 22.000 - 610.000 |
| Total dissolved solids | 720.000 - 28,970.000 |
| Turbidity | 2.770 - 505.000 |
| Total hardness | 130.000 - 1,851.000 |
| Major chemical constituents | |
| Ammonia | 0.000 - 1.770 |
| Nitrate | 0.300 - 1.900 |
| Phosphorus | 0.200 - 1.200 |
| Sulfate | 130.000 - 20,000.000 |
| Chloride | 3.600 - 481.000 |
| Aluminum | 66.000 - 1,200.000 |
| Iron | 0.060 - 4,700.000 |
| Manganese | 90.000 - 180.000 |
| Sodium | 160.000 - 1,260.000 |
| Trace element constituents | |
| Arsenic | 0.005 - 0.600 |
| Beryllium | <0.010 - 0.070 |
| Cadmium | <0.001 - 0.003 |
| Chromium | 0.000 - 16.000 |
| Cobalt | 0.025 - - |
| Copper | 0.010 - 3.900 |
| Magnesium | 0.000 - 174.000 |
| Mercury | <0.0002 - 0.007 |
| Nickel | 0.240 - 0.750 |
| Selenium | <0.001 - 0.030 |
| Zinc | 0.006 - 12.500 |

---

[a] Fred C. Hart Associates, Inc., The Impact of RCRA (PL94-580) on Utility Solid Wastes, EPRI FP-878, August 1978, p. 54.

## 3.5 Model Plant Waste Quantities

Several studies have been made to develop estimates of the quantities of solid waste generated by electric utilities. One such study, published by TVA and EPA, will be used here as a source of waste quantitites for a 500-MW model plant. The plant is assumed to have an initial load factor (% of time in operation) of 80 percent. The load factor is assumed to decline over time as is explained in sections below. The TVA study will also be used below as a source of disposal cost estimates. (For a full reference see Table 3-14.)

The specifications for the model plant used as the basis for estimating quantities are listed in Table 3-14. All of the factors listed have some influence on solid waste quantities. In the specifications it should be noted that the ash content of the coal is a moderately high 16 percent, and the sulfur content is a substantial 3.5 percent. Quantity estimates when these assumptions are varied are given below. Another influence on the waste quantities is the load factor (operating time), here assumed to be 80 percent. Older plants which are used more sparingly generally have lower load factors and this would have a direct effect on waste quantities.

The solid waste generated by the 500-MW model plant consists of 28.1 MT/hr of FGD sludge and 24.5 MT/hr of fly ash (dry weights). In the TVA study only fly ash is considered. However, the model plant characteristics specify the split factor of fly ash to bottom ash to be 80 to 20. Accordingly, 6.1 MT/hr of bottom ash is also generated. The total waste generation is 58.7 MT/hr by dry weight or 117.4 MT/hr by wet weight, with an assumed

## TABLE 3-14
## MODEL PLANT CHARACTERISTICS - TVA STUDY[a]

| ASSUMPTIONS | DATA |
|---|---|
| Plants | |
| Units | 500 MW - single unit |
| Load Factor | 80% |
| Location | Midwest |
| Coal | |
| Ash content | 16% |
| Fly ash/bottom ash | 80/20 |
| Sulfur content | 3.5% |
| FGD system (limestone scrubber) | |
| Scrubber efficiency ($SO_2$ removal) | 65%-85% |
| Scrubbing reagent | Limestone |
| Stoichiometric ratio (Ca/S removed) | 1.5 |
| Slurry to pond (% solids) | 15% |
| Settled slurry | 50% |

---

[a] Barrier, J.W., et al., Economics of Disposal of Lime/ Limestone Scrubbing Wastes: Untreated and Chemically Treated Wastes, EPA-600/7-78-023a, February 1978.

50 percent water content. Annual waste generation amounts to 410,900 MT dry metric tons of waste material assuming an operating time of 7,000 hours. The contribution of each component of the waste stream is 196,700 metric tons of FGD sludge, 171,500 metric tons of fly ash, and 42,700 metric tons of bottom ash.

Waste quantity estimates for variations in plant characteristics are shown in Table 3-15. Several of the variations provide interesting information on the sensitivity of waste quantities to the type of coal burned. Most of the relationships between a given coal characteristic and the related solid waste quantity are estimated to be roughly proportional. However, sludge volumes change more than proportionately for a given change on sulfur content. For example, if the sulfur content of input coal is only 2 percent, rather than the base case sulfur content of 3.5 percent (a reduction of 43 percent), then the hypothetical plant would produce only 27,000 lb/hr of scrubber sludge, a reduction in sludge volume of 54 percent. The total hourly waste volume (fly ash and sludge) falls from 116,000 to 81,000 lb/hr. If the sulfur is 5 percent, the scrubber sludge volume jumps to 97,000 lb/hr, an increase of 56 percent over the base case.

Waste quantities are significantly lower for plants using low ash western coals. Ash quantities could be one-half or one-third those of the base plant. Also, the use of lime rather than limestone reduces the volume of scrubber sludge significantly. The lime scrubbing system produces 47,000 lb/hr as compared to 62,000 lb/hr, a drop of nearly 25 percent.

TABLE 3-15

TOTAL QUANTITY OF ASH AND SLUDGE FOR DISPOSAL - TVA-EPA MODEL PLANT[a]

| | UNTREATED SOLID WASTE[b] | | |
|---|---|---|---|
| | DRY, lb/hr | SHORT TONS/yr | METRIC TONS/yr |
| Base case[c] | 116,000 | 406,000 | 368,000 |
| Variations from base case: | | | |
| 200 MW | 48,000 | 168,000 | 153,000 |
| 1,500 MW | 348,000 | 1,219,000 | 1,106,000 |
| 12% ash in coal | 96,000 | 336,000 | 305,000 |
| 20% ash in coal | 139,000 | 487,000 | 442,000 |
| 2% S in coal | 81,000 | 285,000 | 258,000 |
| 5% S in coal | 151,000 | 529,000 | 480,000 |
| 200 MW, no fly ash | 25,000 | 88,000 | 80,000 |
| 500 MW, no fly ash | 62,000 | 217,000 | 197,000 |
| 1,500 MW, no fly ash | 185,000 | 648,000 | 588,000 |
| Lime scrubbing process | 101,000 | 354,000 | 321,000 |

---

[a] Barrier, J.W., et al., Economics of Disposal of Lime/Limestone Scrubbing Wastes: Untreated and Chemically Treated Wastes, EPA-600/7-78-023a, February 1978.

[b] Bottom ash quantities are excluded.

[c] See Table 3-14.

### 3.5.1 Average Oil Ash Quantities

Although the ash generation from coal-fired boilers far outweighs the ash generation from oil-fired burners, utilities using oil-fired burners are expected to be generators. Ash quantities are generally greater than 100 kg/month from utility-sized oil-fired burners.

The ash proportion of most fuel oils is typically only 0.1 percent by weight.[22] However, a 50-MW output boiler operating at 70 percent capacity and burning fuel oil with 0.1 ash content will generate a total of 6,770 kg of ash per month. To generate 100 kg/month of ash, only 1.5 percent of the ash need be retained in the boiler or in a particulate control device. For larger boilers, higher ash fuels, or higher capactiy levels, proportionately smaller percentage of the ash need be retained to qualify the utility as a generator.

Those boilers that are equipped to burn both coal and oil have particulate control devices. Thus, they qualify as generators whether they are burning coal or oil. Those utilities who burn just oil or oil and natural gas will also be generators.

Utilities may collect the ash in any of a number of ways. Thirteen companies are reported to collect the fly ash from combustion and then sell the ash for vanadium recovery.[23] One utility recovering vanadium reports that boiler washes at their 600-MW oil-fired boiler generate 12.25 $m^3$ of sludge eight times per year.[24] Assuming a specific gravity of 1.5, this material weighs 18.375 metric tons, for a total of 147 metric tons per year. In other cases, only bottom ash is accumulated. These quantities are quite small relative to fly ash, but may exceed 100 kg/month. In addition, ash is collected from residues deposited on boiler surfaces as well as tubes, air preheaters, economizers, etc., during periodic boiler washdown and cleaning. The percent of ash that is retained in the boiler varies from boiler to boiler. From discussions with utilities and boiler manufacturers, a figure of 5 percent of the total ash will be assumed to be retained in the boiler and periodically collected.[25] At this rate, a 50-MW boiler will generate an average of 340 kg of bottom ash per month.[26]

In addition, for aggregate waste generation estimates, an estimated 15 percent of the total fly ash generated is assumed to be collected by firms that employ a coal-oil boiler equipped with particulate control for fly ash control. Thus, 20 percent of the total ash in oil as combusted is assumed to be generated by oil-burning utilities. Based upon 0.1 percent ash by weight in oil, and a consumption of $5.65 \times 10^8$ barrels of oil, approximately 20,000 metric tons of oil ash is estimated to have been generated (i.e., collected) in 1977 by all oil-fired boilers.

### 3.6 Aggregate Waste Quantities

The aggregate quantity of coal ash generated in a year by the electric utility industry is estimated annually in a survey of all coal-fired utility plants by the National Ash Association. In 1977, the survey reported the following aggregate quantities of ash by type: fly ash - 44.0 million metric tons (48.5 million tons); bottom ash - 12.8 million metric tons (14.1 million tons); and boiler slag - 4.7 million metric tons (5.2 million tons). The total ash generation in the survey report is 61 million metric tons.[27]

The estimates of ash quantities appear to be reasonably accurate in that an estimation procedure based upon ash production at a model plant provides similar results. In order to develop the estimate of ash quantities, the model plant, with characteristics as shown in Table 3-14 above, was used. As stated above, the plant would produce 214,200 metric tons of ash per year while providing 3.5 billion kWh of electricity. Assuming this plant produces ash at the average rate for coal-burning utilities then the national production of coal ash can be derived. Coal-burning utilities generated 985 billion kWh of electricity in 1977. The aggregate quantity of coal ash produced in 1977 is therefore estimated to be 60.3 million metric tons. This figure is extremely close to the National Ash Association's figure of 61.5 million metric tons, suggesting that the Association's survey was exhaustive.

The aggregate quantity of flue-gas-desulfurization scrubber sludge is a direct function of the number of FGD systems operating in the country. To date, only a small fraction of the total coal-fired generating capacity has been fitted with scrubbers. However, the institution of New Source Performance Standards for air quality by EPA will change the situation dramatically. In 1975, 2.5 billion kWh were generated by utilities with FGD systems. For 1985, when many new plants with the required scrubbers will have come on line, an estimated 500 billion kWh will come from plants with FGD systems.[28] Estimated national quantities of ash and sludge are shown in Table 3-16. Assuming once again that the model plant characteristics are averages for the utility industry, the total national quantity for 1975 would have been 126,000 metric tons. The national figure will expand rapidly to 28.1 million metric tons in 1985.

### TABLE 3-16

### ESTIMATED AGGREGATE QUANTITIES OF ASH AND SLUDGE[a]

| | MM METRIC TONS | | | MM kWh FROM COAL-FIRED PLANTS[b] |
|---|---|---|---|---|
| | COAL ASH | FGD SLUDGE | COMBINED | |
| 1977 | 60.3 | 3.7[c] | 64.0 | 985,000 |
| 1980 | 75.3 | 11.2[d] | 86.5 | 1,230,000 |
| 1985 | 97.6 | 28.1 | 125.7 | 1,595,000 |

[a] ERCO estimate.

[b] Edison Electric Institute, Annual Electric Power Survey, April 1977.

[c] It was assumed that the quantity of sludge generated in 1977 was three times the 1975 figure of 1.225 million metric tons.

[d] SCS Engineers, Data Base for Standards/Regulations Development for Land Disposal of Flue Gas Cleaning Sludges, EPA, December 1977.

## 3.7 Number of Generators

Approximately 400 utilities are currently burning coal, although the number varies somewhat as some utilites switch between coal and oil. The number of firms burning only oil, and which are generators due to oil ash residues, is 350.[29]

## 3.8 Current Disposal Practices

Current disposal practices have improved during the 1970's, largely under the impetus of state regulations. In this section disposal practices for ash and sludge systems and for ash systems are surveyed. An additional section measures the extent of productive use.

### 3.8.1 Ash and FGD Sludge Systems

As of June 1978 there were 41 FGD systems operating in the United States.[30] Disposal ponds for FGD sludge and coal ash have been unlined for the most part. A summary of disposal practices as reported for 36 of these systems is shown below in Table 3-17. A disposal method was not reported for the other systems.

Given the relatively large number of unlined ponds, this disposal method will be used as the baseline technology for the industry in the cost estimates. A number of states have moved to regulate disposal techniques. Emphasis has been placed on insuring the eventual reuse of the land. Thus disposal techniques are improving in response to RCRA. Part of this activity can be interpreted as RCRA-inspired, and therefore part of the RCRA impacts. Therefore, no reduction in RCRA impacts will be considered due to the level of state activity.

TABLE 3-17

CURRENT DISPOSAL PRACTICES FOR FGD SLUDGE[a]

| DISPOSAL METHOD | NUMBER OF SYSTEMS |
|---|---|
| Unlined pond - no treatment | 19 |
| Lined pond | 5 |
| Fixation | 6 |
| Landfill - no treatment | 5 |
| Mine disposal | 1 |
| Total | 36 |

[a] SCS Engineers, Data Base for Standards/Regulations Development for Land Disposal of Flue Gas Cleaning Sludges, EPA, December 1977.

### 3.8.2 Ash Disposal

Ash disposal is done by either wet (ponding) or dry (landfilling) methods. A survey by the National Ash Association reported that 50 percent of the industry used each method. The Association also reports that the current trend appears to be toward dry disposal. Some utilities have moved in this direction under the regulatory eye of state agencies.[31]

For ponding disposal, a wet slurry is generally used to convey ash to the disposal pond. The water may then be recycled to the plant or discharged, in which case an NPDES permit would be required. Slurry systems work most easily if they can use gravitational forces. As a result, many utilities have chosen low-lying areas for ash ponds.[32]

Ash settles to a high solids content of from 60 to 90 percent. In some cases a utility will build a pond with a sloped basin. At the low end of the basin, facilities are constructed for recycling water to the plant. Ash is then dumped at the high end, and the water content migrates downhill. This practice provides for more rapid dewatering of the ash.

Landfill techniques vary among utilities. A number of firms, particularly those operating in states with RCRA-type legislation, have actively upgraded their landfill practices. Some firms report they have been able to reduce leachate production to a minimum. Other firms, however, appear to be using simple landfilling or landplacing (no cover). At such sites, the only compaction of the ash may be due to the truck traffic over the land which is generated by the dumping operation.[33]

### 3.8.3 Commercial Utilization

A survey by the National Ash Association indicated that approximately 20 percent of all coal ash was commercially utilized. The highest rates of utilization were for bottom ash and boiler slag at 33 and 60 percent respectively. The breakdown of the various uses are shown in Table 3-18.

## 3.9 RCRA Required Treatments

Wastes from electric utilities are treated in entirely different fashions under the two sets of RCRA draft regulations. Under Option A, utility wastes would be treated in the same fashion as other hazardous waste streams. The general facility requirements of Section 3004 would then apply (assuming that the waste is hazardous). Under Option B, special facility requirements are to be defined. To date, the new facility requirements have not been announced. In the following sections, possible disposal requirements under each option will be specified.

Retrofitting will be defined as closure of the existing disposal site (with a clay cap) and development of a new site. No consideration has been given to the possibility of excavating existing sites.

Chemical stabilization methods have been included as disposal options under both Options A and B. Existing methods on the market include the IUCS system and the Dravo system. These stabilization or fixation methods convert utility sludge and ash into either a soil-like material or a hard, impermeable material. In either case, the leachate

## TABLE 3-18

## ASH UTILIZATION

| METHOD OF UTILIZATION | FLY ASH (%) | BOTTOM ASH (%) | BOTTOM SLAG (%) |
|---|---|---|---|
| Commercial utilization | | | |
| Cement uses | 37 | 2 | 3 |
| Lightweight aggregate | 2 | 3 | - |
| Fill material for roads, dikes, construction | 20 | 20 | 8 |
| Stabilizer for road bases, parking areas, etc. | 3 | 5 | 2 |
| Filler in asphalt mix | 2 | - | - |
| Ice control | - | 22 | 13 |
| Blast grit and roofing granules | - | - | 48 |
| Miscellaneous[a] | 3 | 9 | 22 |
| Other ash removed from plant site | 7 | 17 | 4 |
| Ash utilized after initial disposal | 26 | 22 | 1 |
| Total | 100 | 100 | 100 |
| Total ash utilized[b] (MM metric tons) | 5.7 | 4.2 | 2.8 |
| Percent of total ash collected | 13 | 32.6 | 60 |

[a] Ultimate use not specified.

[b] National Ash Association, Ash at Work, September 1978.

produced will probably be acceptable according to the RCRA toxicity test.[34]

Certain factors could not be considered in the cost estimates. Location factors, such as the RCRA stipulation that facilities should not be located in a 100-year floodplain, were not considered. Other crucial assumptions, such as the presence of clay on-site, are described in sections below.

### 3.9.1 RCRA Option A - Required Treatments

The facility requirements specified under Option A for surface impoundments and landfills are described in Table 3-19. The surface impoundments criteria will be used to develop ponding costs for new facilities fitted with FGD

TABLE 3-19

GENERAL HWMF REQUIREMENTS
UNDER RCRA (OPTION A)[a]

| OPTION NUMBER | REQUIREMENTS FOR SURFACE IMPOUNDMENTS OR LANDFILLS | | |
|---|---|---|---|
| | LINER | CAPPING | COVER |
| 1 | Clay (10-ft thick) | Clay (6-in. thick) | Soil (18-in. thick) |
| 2 | Double liner[b] clay (5-ft thick) | Clay (6-in. thick) | Soil (18-in. thick) |
| 3 | Chemical stabilization | - | - |

[a] U.S. Environmental Protection Agency draft regulations for Section 3004, March 1978.

[b] For the double liner case, it will be assumed that a clay liner and an artificial liner are used.

systems. For retrofitting, it will be assumed that existing sites are closed. Disposal is then carried out in a hazardous waste landfill. Alternatively, it would have been possible to assume disposal in a surface impoundment.

A third option, not explicitly mentioned in RCRA regulations, is the use of chemical stabilization methods. It was assumed that these methods would represent acceptable treatments under RCRA, and cost estimates will be provided below for one such system.

### 3.9.2 RCRA Option B - Required Treatments

Facility requirements have not been specified for the disposal of wastes from electric utilities. In the sections below, several treatments will be costed as possible under Option B. However, aggregate technical costs for disposal will be assumed to be zero. This approach appeared most consistent with the current form of RCRA regulations.

## 3.10 Cost Estimates

There are numerous elements to the total compliance costs which may be incurred by electric utilities. The principal cost categories are capital investments, incremental operating and maintenance expenditures, and administrative costs. Capital investment costs are presented in the sections below; incremental operating and maintenance expenses have not been discussed separately. They are included, however, in the estimates of disposal costs per metric ton of waste. Administrative costs are presented separately in Section 3.10.5.

The capital investment costs include the following:

1. Land costs and site preparation costs
2. Liner costs
3. Leachate collection and treatment facilities
4. Other RCRA disposal requirements (monitoring wells, fencing).

The most important assumptions about these elements are discussed below and in the following section on cost estimation methodology.

Disposal cost estimates are provided for two general disposal cases. First, the costs of RCRA-specified disposal for new coal-fired power plants will be examined. The new plant costs are for the disposal of ash and sludge. Second, retrofit costs are provided for ash disposal. The first set of estimates will be used as representative of present and future disposal costs for sludge or sludge and ash combined. The second set of estimates will be used to represent ash disposal costs.

The cost estimates presented here are designed to be representative of the costs which may be incurred by utilities. A number of cost parameters were selected as being indicative of the compliance requirements which firms will face. It was not possible in this study to take into account the variability in these cost parameters. A summary of these parameters and some possible variations are provided below. The scope of this project did not allow the opportunity to model the influence of variability in these factors.

Waste Characteristics - It was assumed that coal ash and scrubber sludge would be uniformly considered hazardous. Wastes from some plants may not actually be hazardous.

Waste Quantities - The quantities from the model plant (Section 3.3) were used. Ash content is thus set at 16 percent and sulfur content is 3.5 percent. For the retrofit case (ash only), ash content is also 16 percent. For the worst-case plant, ash content was increased to 20 percent.

In-place Soils and Regional Variations in Costs - It was assumed that impermeable clay soils are available at the disposal site. Costs were estimated for spreading and placing clay soils to the RCRA-specified thicknesses (5 ft and 10 ft). No estimate was made for disposal at sites where natural in-place soils can be utilized without any additional excavation or construction costs. This assumption was taken as a rough average of necessary construction activities. In the eastern United States, varying thicknesses of in-place soils may be available. In many western areas, no impermeable soils may be available in the vicinity of the disposal site.

Land Costs - Suitable land for the disposal site was assumed to be available at a cost of $3,500 per acre. The distance to the disposal site was set at 1 mile for the new plant, 2 miles for the retrofit plant, and 5 miles for the worst-case plant. No additional consideration was made of the effect of RCRA prohibitions concerning siting in wetlands areas, floodplains, or near-surface waters.

### 3.10.1 Cost Estimation Methodology

The costs of disposal by ponding presented here are based on those provided in a study published jointly by TVA and EPA entitled The Economics of Disposal of Lime/Limestone Scrubbing Wastes: Untreated and Chemically Treated Wastes (Authors J.W. Barrier, H.L. Fawcett, and L.J. Henson). The TVA study estimated costs of disposal for the 500-MW plant used here. The study also examined a number of variations to the base case including changes in the disposal method and the size of the facility. Landfill costs are based (with a number of modifications) on the methodology used in a report published by the Electric Power Research Institute entitled State-of-the-Art of FGD Sludge Fixation (Authors: Michael Baker, Jr. Associates).

Cost estimates are based on the expected disposal costs for a new 500-MW coal-fired unit and for a 10-year-old 500-MW plant. In each case the total expected life of the facility is 30 years. The new plant is assumed to be fitted with an FGD system which collects both ash and sludge. Descriptions of the waste generation rate and characteristics of the emission control system are provided above in Section 3.5. The disposal pond is assumed to be 1 mile from the plant.

A 500-MW facility rather than a larger facility was chosen in order not to underestimate costs due to economies of scale in disposal operations. However, the cost estimation techniques used here for estimating landfill costs are relatively insensitive to economies of scale. Thus unit cost estimates for a 1,000-MW or 1,500-MW facility would be only slightly lower.

The 10-year-old plant is assumed to be basically the same facility as the new 500-MW unit with the exception that no scrubber system is in place. Current disposal practices consist of sluicing coal ash to an unlined pond. Under RCRA (Option A) the ash pond is allowed to dry and then capped. For most ash ponds, dewatering costs would be incurred. Landfill operations are then started. The landfill area is located 2 miles from the plant. It was assumed that no equipment costs were incurred for the ash handling equipment at the plant. Many plants have the capability for wet or dry ash handling (see reference cited in note 27).

An important assumption concerns the expected operating profiles for the two facilities. The capacity factors for the two plants are described below in Table 3-20. The operating schedules are derived from the TVA report and are based on TVA's experience with electrical generation.

TABLE 3-20

OPERATING PROFILES FOR MODEL PLANTS[a]

| NEW PLANT | | | 10-YEAR-OLD PLANT | | |
|---|---|---|---|---|---|
| YRS OF LIFE | CAPACITY FACTOR | ANNUAL OPERATING HOURS | REMAINING YRS | CAPACITY FACTOR | ANNUAL OPERATING HOURS |
| 1-10 | 80 | 7,000 | 1-5 | 57 | 5,000 |
| 11-15 | 57 | 5,000 | 6-10 | 40 | 3,500 |
| 16-20 | 40 | 3,500 | 11-20 | 17 | 1,500 |
| 21-30 | 17 | 1,500 | | | |
| Avg. | 48.5 | 4,250 | Avg. | 32.8 | 2,875 |

[a]Based on operator profiles in Economics of Disposal of Lime/Limestone Scrubbing Wastes: Untreated and Chemically Treated Wastes, EPA, February 1978.

Other elements of the cost estimation procedure are described below:

1. The shorter operating hours and the absence of an FGD system mean that a considerably smaller volume of waste will need to be handled in the retrofit facility. The average dry weight of waste to be handled annually is 88,000 MT for the older plant and 224,000 MT for the new plant.

2. The annual revenue requirements include necessary capital charges (including a rate of return) and operating and maintenance costs. The contribution of the latter varies depending on the system component being considered. The O&M expenses of the landfill operation (ash loading transport, compacting) are included in the annual revenue requirements for the landfill site (unimproved).

3. Capital charges are slightly higher for retrofitting investments due to the retirement of costs in a shorter time period. The difference in annual capital charges between the new and retrofit disposal sites amount to 1 percent of total investment.[35]

4. The clay used for lining is assumed to be available on-site. The cost of excavation and placing of the clay is assumed to be \$2.50/yd$^3$, as was used in the published TVA estimates.[36] If clay is brought from off-site then costs would be dependent on the transport distance. The artificial liner costs were set at \$4.50/yd$^2$, roughly equivalent to the cost of a hypalon or chlorinated polyethylene

liner with a thickness of 30 mils.[37] Less expensive liners could have been proposed for use. The TVA study includes estimates for liners costing from $1.50 to $4.50 per square yard. However, none of the currently available liners appear to have the durability for long-term use in a landfill.[38] As a result, the most expensive liner was assumed to be necessary.

5. For disposal of ash and sludge in a new plant, a baseline cost of $7.51 per metric ton was used. This figure, as estimated by TVA, represents the cost of disposal in an unlined pond. For landfilling, a baseline cost of $3.00/MT was used. The figure was chosen as representative for landfill operations which began 10 years ago, that is, for the model plant to be retrofitted. The range of disposal costs at existing sites ranges from $1.50 to $5 per metric ton.

6. The cost estimates labeled "chemical stabilization" refer to costs derived from the TVA study for the IUCS system. Another stabilization system, the Dravo system, was estimated by TVA to have a higher price. Only the IUCS system costs are presented here on the assumption that, other factors being equal, the model plant would choose the lower cost system. The comparability of the systems was not assessed.

7. No costs are included for dewatering of the existing sites. For ash ponds, it was assumed that they would dry to a solids content which would allow capping. Retrofit costs for

ash/sludge ponds were not included due to the small number of plants to which they would apply. However, if dewatering is undertaken at these plants, it would involve a substantial additional cost.

8. Closure costs are included in the financial responsibility costs described below. If they were provided here as a separate component, they would not change the results greatly due to the small present value of expenditures to be made 20 to 30 years hence.

An appendix explaining the cost estimation procedures in greater detail is included at the end of this report.

### 3.10.2 Option A Costs

The costs of RCRA compliance under Option A are shown for a new 500-MW plant in Table 3-21. The baseline cost estimate is $7.51/MT. Addition of either of the first two disposal options, a 10-foot clay liner or a 5-foot clay liner combined with an artificial liner, increases the disposal costs substantially. The least cost option is clearly chemical stabilization, which is costed at approximately $14/MT. In fact the chemical stabilization option is shown to require a lower capital investment than the unlined pond. Operating expenses, however, bring the cost up to the $14/MT level.

Disposal costs are presented in terms of the applicable annual revenue requirements. Annual revenue requirements include capital charges (including provision for a rate of return on equity) and operating and maintenance expenses.

TABLE 3-21

COSTS FOR DISPOSAL OF ASH AND SLUDGE (OPTION A)[a,b]

| DISPOSAL OPTIONS | TOTAL CAPITAL INVESTMENT ($000) | TOTAL ANNUAL REVENUE REQUIREMENT ($000) | UNIT REVENUE REQUIREMENT | |
|---|---|---|---|---|
| | | | $/MT (dry) | mills/kWh |
| Baseline: | | | | |
| Unlined pond | 14,391 | 2,765 | 7.51 | 0.79 |
| Option 1: | | | | |
| Clay liner (10-ft) | 17,227 | 3,032 | 8.23 | 0.86 |
| Option 2: | | | | |
| Clay liner (5-ft) | 7,656 | 1,347 | 9.47 | 0.99 |
| Artificial liner ($4.50/yd$^2$) | 12,316 | 2,141 | | |
| Subtotal | 19,723 | 3,445 | | |
| Option 3: | | | | |
| Chemical stabilization | (3,674) | 2,526 | 6.32 | 0.72 |
| Additional elements: | | | | |
| Collection system | 216 | 52 | 0.14 | 0.01 |
| Monitoring wells | | | | |
| Leachate treatment | | | | |
| Fencing | | | | |
| Total Option 1 | 31,834 | 5,849 | 15.88 | 1.66 |
| Total Option 2 | 34,330 | 6,262 | 17.12 | 1.79 |
| Total Option 3 | 10,933 | 5,343 | 13.97 | 1.51 |

[a] ERCO estimates and Barrier, J.W. et al., Economics of Disposal of Lime/Limestone Scrubbing Wastes: Untreated and Chemical Treated Wastes, February 1975.

[b] Costs are for a new 500-MW plant where the ash is assumed to be hazardous.

Simply speaking, the annual revenue requirements represent annualized compliance costs.

The costs of retrofitting are outlined for the model plant in Table 3-22. A baseline or current cost of disposal of $3/MT has been assumed. Under RCRA the existing site is closed with a 6-inch clay cap and a new landfill site is prepared. The basic capital investment for the site has been calculated at approximately $0.5 million. The site improvements are, again, a 10-foot clay liner, or a 5-foot liner combined with an artificial liner. The necessary capital investments for these improvements are modest compared to those of the new plant costs. Here they are estimated at $3.7 to $3.8 million for each disposal option. The cost per metric ton of waste nevertheless increases from $3/MT to $11.48/MT.

### 3.10.3 Worst-Case Costs

A wide number of options were available to define the worst-case costs. Variables which could be manipulated include: (1) transportation costs, (2) liner costs (adding costs for importing clay), (3) ash content, (4) sulfur content (in the case of scrubber sludge), (5) plant load factors, (6) plant size, and several others. For this analysis, three variables were chosen to define worst-case costs. These are listed below in Table 3-23. The estimates are for retrofitting a 500-MW plant with a 20-year remaining life. The retrofit case was judged to have the widest applicability and was therefore used in the definition of worst-case costs. In the worst-case, the transportation distance for the waste was changed only from 2 to 5 miles. However, a very liberal transportation cost per ton of

## TABLE 3-22

## RETROFITTING COSTS FOR ASH DISPOSAL (OPTION A)[a,b]

| COST COMPONENT | TOTAL CAPITAL INVESTMENT ($000) | TOTAL ANNUAL REVENUE REQUIREMENT ($000) | UNIT REVENUE REQUIREMENT | |
|---|---|---|---|---|
| | | | $/MT (dry) | mills/kWh |
| Baseline: | | | | |
| Ponding or landfill | | | 3.00 | |
| Landfill site | 536 | 400 | 4.54 | 0.29 |
| Clay cap (6 in.) (old site) | 815 | 152 | 1.73 | 0.11 |
| Option 1: | | | | |
| Clay liner (10-ft) | 2,311 | 430 | 4.89 | 0.31 |
| Option 2: | | | | |
| Clay liner (5-ft) | 1,156 | 215 | | |
| Artificial liner ($4.50/yd$^2$) | 1,248 | 232 | 5.08 | 0.32 |
| Subtotal | 4,404 | 447 | | |
| Additional elements: | | | | |
| Collection system<br>Monitoring wells<br>Leachate treatment<br>Fencing | 78 | 28 | 0.32 | 0.02 |
| Total Option 1 | 3,740 | 1,010 | 11.48 | 0.73 |
| Total Option 2 | 3,833 | 1,027 | 11.67 | 0.74 |

[a] ERCO estimates.

[b] 20-year remaining life for 500-MW plant.

## TABLE 3-23
## WORST-CASE ASSUMPTIONS

| ITEM | MODEL PLANT | WORST-CASE |
|---|---|---|
| Distance in disposal site | 2 miles | 5 miles |
| Ash content | 16% | 20% |
| Average annual load factor | 32.8% | 60% |

75 cents per ton was used and thus possible increases in transportation costs are more than adequately covered.

The increased transportation distance increases the cost per ton of ash diposed. The increased ash content and load factor increase the size of the necessary capital investment. However, these changes tend to reduce the cost per ton of ash disposed. As a result, the overall cost per ton of disposal in the worst-case is only slightly higher than that for the model plant.

The cost components for the disposal site are shown below in Table 3-24. The basic landfill site costs are substantially higher than those of the model plant. Also the total capital investment for the system is approximately 75 percent higher than for the model plant. An increase of approximately 25 percent is estimated for the cost per kilowatt hour generated by the worst-case plant. Table 3-25 below provides a comparison of several of the major components of the model and worst-case disposal.

## TABLE 3-24

## WORST-CASE RETROFIT COSTS[a,b]

| COST COMPONENT | TOTAL CAPITAL INVESTMENT ($000) | TOTAL ANNUAL REVENUE REQUIREMENT ($000) | UNIT REVENUE REQUIREMENT | |
|---|---|---|---|---|
| | | | $/MT (dry) | mills/kWh |
| Baseline: | | | | |
| Ponding or landfill | | | 3.00 | |
| Landfill site | 765 | 1,289 | 0.76 | 0.49 |
| Clay cap (6 in.) (old site) | 815 | 152 | 4.49 | 0.06 |
| Option 1 | | | | |
| Clay liner (10-ft) | 4,852 | 902 | 4.67 | 0.34 |
| Option 2 | | | | |
| Clay liner (5-ft) | 2,426 | 451 | 0.21 | 0.36 |
| Artificial liner ($4.50/yd$^2$) | 2,620 | 487 | | |
| Subtotal | 5,046 | 938 | | |
| Additional elements | | | | |
| Collection system<br>Monitoring wells<br>Leachate treatment<br>Fencing | 149 | 43 | 0.21 | 0.02 |
| Total Option 1 | 6,581 | 2,386 | 11.88 | 0.91 |
| Total Option 2 | 6,775 | 2,422 | 12.06 | 0.93 |

---

[a] ERCO estimates. It was assumed that the wastes would be hazardous for the worst-case plant.

[b] 20-year remaining life on 500-MW plant, assumes 20 percent ash content in coal.

TABLE 3-25

MAJOR RESULTS OF MODEL AND WORST-CASE DISPOSAL CASES[a,b]

| COST ESTIMATE | MODEL PLANT | WORST-CASE PLANT |
|---|---|---|
| Total capital investment ($) | 3,740,000 | 6,581,000 |
| Cost/MT of disposal ($) | 11.48 | 11.88 |
| Cost (mills/kWh) | 0.73 | 0.91 |

[a] ERCO estimate.

[b] Comparison is made assuming use of a 10-ft clay liner.

### 3.10.4 Option B Costs

Two disposal options are provided under Option B. The options and related costs are shown in Table 3-26. The first involves the addition of a 1-foot clay liner to the baseline method (unlined pond). The second option involves chemical stabilization. The clay liner adds a relatively modest $1.40 to disposal costs. As in Option A, chemical stabilization increases the total cost of disposal to approximately $14/MT.

Possible retrofit costs are shown in Table 3-27. In this case it has been assumed that landfilling of dry ash would be acceptable. Disposal costs consist only of developing the landfill site and capping the old site.

If the assumption about liners is modified, costs, of course, increase. Addition of a 1-foot clay liner would add approximately $0.50 to the disposal cost per metric ton.

## TABLE 3-26

## COSTS OF DISPOSAL OF ASH AND SLUDGE - OPTION B NEW 500-MW PLANT[a]

| DISPOSAL OPTIONS | TOTAL CAPITAL INVESTMENT ($000) | TOTAL ANNUAL REVENUE REQUIREMENT ($000) | UNIT REVENUE REQUIREMENT | |
|---|---|---|---|---|
| | | | $/MT (dry) | mills/kWh |
| Baseline: | | | | |
| Unlined pond | 14,391 | 2,765 | 7.51 | 0.79 |
| Option 1: | | | | |
| Clay liner (1-ft) | 2,820 | 515 | 1.40 | 0.15 |
| Option 2: | | | | |
| Chemical stabilization | 3,674 | 1,347 | 9.47 | 0.99 |
| Additional elements: | | | | |
| Collection system<br>Monitoring wells<br>Leachate treatment<br>Fencing | 216 | 52 | 0.14 | 0.01 |
| Total Option 1 | 17,427 | 3,232 | 9.04 | 0.94 |
| Total Option 2 | 10,933 | 5,248 | 13.97 | 1.51 |

[a] ERCO estimates based data in *Economics of Disposal of Lime/Limestone Srubbing Wastes: Untreated and Chemically Treated Wastes*, EPA, February 1978.

## TABLE 3-27

## RETROFITTING COSTS FOR ASH DISPOSAL - OPTION B[a]

| COST COMPONENT | TOTAL CAPITAL INVESTMENT ($000) | TOTAL ANNUAL REVENUE REQUIREMENT ($000) | UNIT REVENUE REQUIREMENT | |
|---|---|---|---|---|
| | | | $/MT (dry) | mills/kWh |
| Baseline ponding: | | | 3.00 | |
| Retrofit: | | | | |
| Landfill site | 536 | 413 | 4.70 | 0.30 |
| Clay cap (old site) | 454 | 127 | 1.44 | 0.09 |
| Additional elements: | | | | |
| Collection system<br>Monitoring wells<br>Leachate treatment<br>Fencing | 78 | 28 | 0.32 | 0.02 |
| Total | 1,068 | 568 | 6.46 | 0.41 |

[a] ERCO estimates.

Use of an artificial liner, as shown for Option A, would add $2.64/MT.

In the calculation of aggregate disposal costs, no technical requirements will be included under Option B. This approach is consistent with the absence of technical requirements for utilities under Option B. It is hoped that some of the estimates presented here can be of use in future efforts to cost out other disposal options.

### 3.10.5 Administrative Costs

The varied nontechnical costs of RCRA compliance are described here under the general title of administrative costs. The individual tasks are described in the following tables. The costs attached to each item were derived from a study by another EPA contractor, Arthur D. Little (Integrated Economic Impact Assessment of Hazardous Waste Management Regulations, Preliminary Draft, October 1978). In a number of cases, judgments had to be made as to the applicability of a task or the appropriate size of the relevant costs. Thus the cost estimates should be considered ERCO estimates.

Costs are presented in Tables 3-28 and 3-29 for the administrative costs associated with on-site disposal of wastes under RCRA Options A and B. The large difference in costs is due to the presumed existence in the first case of financial responsibility requirements. The financial responsibility costs were set for Option A at $194,500. This figure is consistent with the "low estimate" of financial responsibility charges for a 20,000 $m^3$ hazardous waste landfill in the ADL report. The "low estimate" was chosen

## TABLE 3-28

## ADMINISTRATIVE COSTS FOR ON-SITE DISPOSAL, ELECTRIC UTILITIES (OPTION A)[a]

| | COST ($) | |
|---|---|---|
| | FIRST YEAR | RECURRING |
| Section 3001: | | |
| 1. Waste analysis[b] | 23,000 | 23,000 |
| 2. Documentation of wastes | 240 | - |
| 3. Supervision of testing | 50 | - |
| Section 3002: | | |
| 1. Application for ID Code | 32 | - |
| Section 3004: | | |
| 1. Surface water monitoring[c] | 28,000 | 28,000 |
| 2. Groundwater monitoring | 10,400 | 10,400 |
| 3. Notification of disposal | 32 | - |
| 4. Reporting of quantities disposed | 1,136 | 1,136 |
| 5. Report of monitoring data | 260 | 260 |
| 6. Develop contingency plan | 493 | - |
| 7. System design for proper facility operation | 2,142 | - |
| 8. Daily inspections | 20,075 | 20,075 |
| 9. Updating of procedures | 811 | 811 |
| Section 3005: | | |
| 1. Develop facility description | 42,600 | - |
| 2. Design financial requirements plan | 1,340 | - |
| 3. Assessment and redesign of facility | 1,730 | |
| 4. Understanding of permit | 1,790 | |
| 5. Training program | 13,750 | 4,500 |
| 6. Design of contingency plan costs | 4,000 | - |
| 7. Contingency supervision | 1,000 | 1,000 |
| Financial responsibility requirements | 194,500 | 194,500 |
| Total | 347,381 | 283,682 |
| Annualized costs | 294,076 | - |

[a] ERCO estimates.

[b] Assumes $2,300/test, 10 tests/year.

[c] $350/sample at 8 sites, 10 times/year.

## TABLE 3-29

## ADMINISTRATIVE COSTS FOR ON-SITE DISPOSAL, (OPTION B)[a]

| | COST ($) | |
|---|---|---|
| | FIRST YEAR | RECURRING |
| Section 3001: | | |
| 1. Waste analysis[b] | 23,000 | 23,000 |
| 2. Documentation of wastes | 240 | - |
| 3. Supervision of documentation | 50 | - |
| Section 3002: | | |
| 1. Notification of generator | 32 | - |
| Section 3004: | | |
| 1. Surface water monitoring[c] | 28,000 | 28,000 |
| 2. Groundwater monitoring | 10,400 | 10,400 |
| 3. Notification of disposal operations | 32 | - |
| 4. Reporting on quantities disposed | 1,136 | 1,136 |
| 5. Report of monitoring data | 260 | 260 |
| 6. System design for proper facility operations | 2,142 | - |
| 7. Daily inspections | 20,075 | 20,075 |
| 8. Updating of procedures | 811 | 811 |
| Section 3005: | | |
| 1. Develop facility description | 42,600 | - |
| 2. Assessment and redesign of faclity | 1,730 | - |
| 3. Understanding of permit | 1,790 | - |
| 4. Training program | 13,750 | 4,500 |
| 5. Supervision of permitting | 1,000 | 1,000 |
| Total | 147,048 | 89,182 |
| Annualized costs | 98,597 | |

[a] ERCO estimates.

[b] Assumes $2,300/test, 10 tests/year.

[c] Assumes $350/sample at 6 sites, 10 times/year.

due to the relatively small risk involved in utility waste disposal compared to other hazardous waste disposal.

Under Option B, firms disposing of wastes at owned, offsite facilities will be required to provide manifests with each shipment of waste. The manifest handling requirements were assumed not to apply to the model firm, which is assumed to be able to dispose of wastes onsite. However, these costs would apply to (1) firms which, in retrofitting, must ship wastes offsite and (2) firms whose current landfill operations involve offsite disposal of wastes. The cost of manifest handling was estimated by ADL at $3 per manifest for generators. For a standardized loading and filling operation, such as for ash disposal, this cost estimate appears to be fairly liberal. The number of truckloads of ash for a 500-MW coal-burning plant would range from 2,000 to 7,000 per year. Thus costs for manifest handling would range from $6,000 to $21,000 annually.[39]

A separate set of administrative requirements is provided for offsite disposal of oil ash. These costs, shown in Table 3-30, will be assumed to apply to oil-fired generating plants. Most of these firms are currently using onsite disposal, but under RCRA it appears likely that they would choose offsite disposal for the small quantities of oil ash generated.

## TABLE 3-30

## ADMINISTRATIVE COSTS FOR OFFSITE DISPOSAL OF OIL ASH[a]

| | OPTION A | | OPTION B | |
|---|---|---|---|---|
| TASK | FIRST YEAR ($) | RECURRING ($) | FIRST YEAR ($) | RECURRING ($) |
| Waste analysis ($2,300/test, 5/year) | 11,500 | 11,500 | 11,500 | 11,500 |
| Documentation of wastes | 240.50 | - | 240.50 | - |
| Supervision of documentation | 50 | - | 50 | - |
| Application for ID code | 31.50 | - | 31.50 | - |
| Reporting of generation | 586 | 586 | 242 | 242 |
| Storage of manifests | 20 | 20 | 20 | 20 |
| Manifest handling ($3/manifest, 1/month) | 36 | 36 | 36 | 36 |
| System design for handling disposal | 993 | - | 993 | - |
| Supervision of system design | 300 | 300 | 300 | 300 |
| Ongoing supervision | 600 | 600 | 600 | 600 |
| Maintenance of test and upgrading of procedures | 214 | 214 | 214 | 214 |
| Totals | 14,571 | 13,256 | 14,227 | 12,912 |
| Annualized costs | | 13,470 | | 13,126 |

[a] ERCO estimate.

## NOTES TO CHAPTER THREE

1. Hecht, N.L. and D.S. Duvale, Characterization and Utilization of Municipal and Utility Sludges and Ashes, Volume II - Utility and Coal Ash (University of Dayton, Dayton, Ohio, 1975), p. 66.

2. Chu, T.Y.J., P.A. Krenkel, and R.J. Ruane, Reuse of Ash Sluicing Water in Coal-Fired Power Plants (Tennessee Valley Authority), p. 29.

3. Hecht, N.L. and D.S. Duvale, 1975.

4. Ray, S.S. and F.G. Parker, Characterization of Ash from Coal-Fired Power Plants (Tennessee Valley Authority), p. 31.

5. O'Gorman, J.V., and P.L. Walker, Jr., Mineral Matter and Trace Elements in U.S. Coal (Office of Coal Research), 1972.

6. Holland W.F., et al., Environmental Effects of Trace Elements from Ponded Ash and Scrubber Sludge (EPRI Report No. 202), September 1975.

7. Michael Baker Jr., Inc., State-of-the-Art of FGD Sludge Fixation (Electric Power Research Institute), January 1978.

8. Michael Baker Jr., Inc., 1978, Section 2.

9. Michael Baker Jr., Inc., 1978, pp. 2-14.

10. Michael Baker Jr., Inc., 1978, Section 2.

11. Michael Baker Jr., Inc., 1978, Section 2.

12. Michael Baker Jr., Inc., 1978, pp. 2-30.

13. Other references include J.W. Rossoff et al., Disposal of By-Products from Nonregenerable Flue-Gas-Desulfurization Systems, Second Progress Report (EPA), May 1977.

14. Comparison of analyses presented in the source work for Table 3-7, Radian Corporation's study, Environmental Effects of Trace Elements from Ponded Ash and Scrubber Sludge, indicates that sizable portions of the elements originated in the lime or limestone inputs to the FGD system.

15. Holland, W.F., et al., 1975.

16. Dressen, D.R., "Comparison of Levels of Trace Elements Extracted from Fly Ash and Levels Found in Effluent Waters from a Coal-Fired Plant," Environmental Science and Technology (October 1977).

17. Fluorine is covered in the RCRA Option A regulations Section 3001, but does not appear in Option B regulations.

18. See, for example, Rossoff, J.W., et al., 1977.

19. Southern Research Institute, Study of Electrostatic Precipitators Installed on Oil-fired Boilers (Electric Power Research Institute, 1978), pp. 3-17.

20. Fred C. Hart Associates, The Impact of RCRA (PL94-580) on Utility Solid Wastes (EPRI FP-878), August 1978.

21. Cox, D.B. and R.J. Ruane, "Characterization of Coal Pile Drainage," U.S. EPA, Second Symposium on Fugitive Emissions: Measurement and Control, May 1977.

22. Southern Research Institute, 1978, pp. 3-15.

23. Personal communication between John Eyraud of ERCO and A.J. O'Neil of Long Island Lighting Co., October 1978.

24. Personal communication between Alisa Gravitz of ERCO and Phil Rock of Boston Edison Co., March 1978.

25. Based on personal communication between Steve Fischer of ERCO and several firms. The range of estimates given was 0 to 20 percent for ash retention.

26. Assumes 0.1 percent ash content, 70 percent load factor, and 5 percent as bottom ash.

27. National Ash Association, Ash at Work, 1978.

28. Exact forecasts of generation from plants with scrubbers have not been developed, pending the final promulgation of New Source Performance Standards. The 500 billion kWh was chosen as a conservative estimate, based upon the incomplete forecasts available.

29. U.S. Department of Energy, Annual Summary, Cost and Quality of Fuels for Electric Utility Plants (1978). Approximately 350 firms had oil deliveries, not counting those firms which also had coal deliveries.

30. SCS Engineers, Data Base for Standards/ Regulations Development for Land Disposal of Flue Gas Cleaning Sludges, December 1977.

31. National Ash Association, 1978.

32. Personal communication between John Eyraud of ERCO and Charles Govin, Wisconsin Electric Power, August 1978.

33. Personal communication between John Eyraud of ERCO and Howard Humphrey of American Electric Power, September 1978.

34. For published evidence of leachate characteristics, see J.W. Rosoff, cited above in note 10.

35. Based on the difference in capital charges for plants with 30-year and 20-year remaining life in the TVA study.

36. Personal communication between John Eyraud of ERCO and Robert Torstrick of TVA, Muscle Shoals, Alabama.

37. Based on the liner costs cited in J.W. Rossoff, p. 155.

38. Personal communication between John Eyraud of ERCO and Robert Landreth of EPA, Cincinnati, August 1978.

39. Based on an assumed truck capacity of 36 $yd^3$ of ash. A cubic yard of ash is estimated to weigh 1.215 tons.

# CHAPTER FOUR

# ECONOMIC IMPACTS ON THE ELECTRIC UTILITY INDUSTRY

The assessment of economic impacts for this industry will vary somewhat from those presented for the other industries covered. As a regulated industry, plant shutdowns and other major economic dislocations are not much of an issue for utilities. The principal impacts are pollution control expenditure and the related increase in electric utility rates. For this reason, only a brief model plant analysis is provided below. Following sections will then present aggregate cost impacts, and regional impacts under the assumption that all ash and sludge is found to be hazardous.

## 4.1 Model Plant Impacts

A detailed examination of the effects of RCRA on the model plant net income was not undertaken as part of this study. As a regulated industry, net income effects are a function of the regulatory treatment of the added expenditures. Several general conclusions will be drawn about the probable magnitude of effects drawing upon the assessment of industry finances and the industry regulatory structure as presented in Chapter Two.

Net profits will decline due to the regulatory lag in recovering costs. The size of the decline depends on the rate of cost inflation and the length of the lag period.

One study of the industry by another EPA contractor simulated the decline in net profits due to the implementation of air emission controls (NSPS).[1] The investment in that case was substantially larger than those considered here. Assuming a 1-year regulatory lag, a net profit decline of 3 to 5 percent was expected for the industry. A similar, perhaps smaller decline can be expected due to RCRA (Option A). By extension, the industry is also likely to experience a small decline in the rate of return on equity.

The sizable capital expenditures required under RCRA Option A would also impinge on the quality of earnings. Current utility earnings include an Allowance for Funds Used During Construction (AFUDC). This balance sheet item represents non-cash income counted in the current period, even though it will be realized in future periods. Increases in the level of construction activity, generally speaking, tend to increase the AFUDC component of earnings. This increase represents a problem for utilities only to the extent that investors shy away from firms with a high non-cash component in earnings. In any case, the effects on AFUDC should be small. The study cited above also indicated small increases in AFUDC due to pollution control investments.[2]

## 4.2 Aggregate Cost Impacts

The total national costs of RCRA compliance are shown below in Table 4-1. Costs are shown based on the estimated waste quantities in 1977 and 1985. In the latter year, large quantities of FGD sludge, in addition to coal ash, are expected to be generated. The total compliance costs for 1977 and 1985 are estimated at $600 million and $1 billion

## TABLE 4-1

## IMPACT OF RCRA REGULATIONS ON AGGREGATE NATIONAL ELECTRIC RATES[a]

| | OPTION A | | OPTION B | |
|---|---|---|---|---|
| | 1977 | 1985 | 1977 | 1985 |
| Total compliance cost (1977 $MM) | 606.6 | 1,003.3 | 44.2 | 49.2 |
| Cost/kWh sold (mills) | 0.31 | 0.37 | 0.023 | 0.018 |
| Average revenue/kWh sold (mills) | 32.09 | 32.31 | 32.09 | 32.31 |
| Increase/kWh to cover RCRA costs (%) | 0.95 | 1.15 | 0.072 | 0.057 |

[a] ERCO estimates based on the assumption that all ash and sludge is found to be hazardous. It is likely that relatively small portions of these wastes would actually be designated as hazardous.

under Option A. The RCRA cost increase is equivalent to 0.31 mills per kWh of total electrical generation or roughly a 1 percent increase in costs per kWh.

Option B costs presented here included only the administrative cost elements of RCRA, pending the definition of technical disposal requirements by EPA. The RCRA administrative costs amount to $44 million and $49 million for 1977 and 1985.

The incremental costs of RCRA compliance are shown by type of utility plant in Table 4-2. Virtually all of the

## TABLE 4-2

## NATIONAL IMPACT OF RCRA FOR THE ELECTRIC UTILITIES INDUSTRY (1977 $MM)[a]

| | OPTION A | | OPTION B | |
|---|---|---|---|---|
| | 1977 | 1985 | 1977 | 1985 |
| Technical disposal costs | | | | |
| Coal wastes | 484.0 | 865.9 | 0 | 0 |
| Oil wastes | 0.3 | 0.4 | 0 | 0 |
| Administrative costs | | | | |
| Coal plants | 117.6 | 132.3 | 39.6 | 44.6 |
| Oil plants | 4.7 | 4.7 | 4.6 | 4.6 |
| Total costs | | | | |
| Coal plants | 601.6 | 998.2 | 39.6 | 44.6 |
| Oil plants | 5.0 | 5.1 | 4.6 | 4.6 |
| Total RCRA costs | 606.6 | 1,003.3 | 44.2 | 49.2 |

[a] ERCO estimates based on the assumption that cell ash and sludge is found to be hazardous. It is likely that relatively small portions of these wastes would actually be designated as hazardous.

compliance costs will be incurred by coal-fired plants under Option A. Compliance costs for oil-fired plants are estimated at $5 million under Option A.

Under Option B, once again, only administrative costs are shown. The large drop in administrative costs between RCRA options is largely due to the absence of financial responsibility costs under Option B. Oil-fired plants accounted for 10 percent of the administrative cost burden under Option B.

## 4.3 Regional Price Impacts

Differential regional impacts will be felt depending upon the proportion of fuel types used in electrical generation. The RCRA compliance costs were allocated among regions based on the amount of coal and oil-fired generation in each. The estimated regional impacts for Option A and B are shown below in Tables 4-3 and 4-4. The results are not hard to predict. The largest cost increases under Option B are noted in the South Atlantic and Mountain regions where coal-fired generation dominates. Small increases are noted for the Pacific and New England regions. Option B impacts are allocated in roughly the same fashion.

In order to better interpret the information included in Tables 4-3 and 4-4, the following regional definitions are provided.

New England - Me., N.H., Vt., Mass., R.I., Conn.

Middle Atlantic - N.Y., N.J., Penn.

East North Central - Ohio, Ind., Ill., Mich., Wisc.

West North Central - Minn., Iowa, Mo., N.D., S.D., Neb., Ks.

South Atlantic - Del., Md., Va., W. Va., N.C., S.C., Ga., Fla.

East South Central - Ky., Tenn., Ala., Miss.

West South Central - Ark., La., Okla., Tx.

## TABLE 4-3

## RCRA IMPACTS ON REGIONAL ELECTRIC RATES (OPTION A)[a]

| | 1977 CENTS/kWh SOLD | | |
|---|---|---|---|
| REGION | REVENUE[b] | RCRA COST | RCRA COST AS % OF REVENUE |
| New England | 4.44 | 0.0029 | 0.065 |
| Middle Atlantic | 4.45 | 0.026 | 0.584 |
| E. North Central | 3.20 | 0.049 | 1.531 |
| W. North Central | 3.26 | 0.046 | 0.014 |
| South Atlantic | 3.37 | 0.040 | 1.186 |
| E. South Central | 2.33 | 0.044 | 1.888 |
| W. South Central | 2.76 | 0.0054 | 0.196 |
| Mountain | 2.73 | 0.055 | 2.015 |
| Pacific | 2.68 | 0.0024 | 0.089 |
| Alaska and Hawaii | 4.39 | 0.0036 | 0.082 |
| United States | 3.21 | 0.031 | 0.95 |

[a] ERCO estimates.

[b] Derived from Edison Electric Institute, Statistical Yearbook 1977, pp. 34-35.

## TABLE 4-4

## RCRA IMPACTS ON REGIONAL ELECTRIC RATES (OPTION B)[a]

| | 1977 CENTS/kWh SOLD | | |
|---|---|---|---|
| | REVENUE[b] | RCRA COST | RCRA COST AS % OF REVENUE |
| New England | 4.44 | 0.00097 | 0.022 |
| Middle Atlantic | 4.45 | 0.0022 | 0.494 |
| E. North Central | 3.20 | 0.0033 | 0.010 |
| W. North Central | 3.26 | 0.0032 | 0.098 |
| South Atlantic | 3.37 | 0.0030 | 0.089 |
| E. South Central | 2.33 | 0.0031 | 0.133 |
| W. South Central | 2.76 | 0.00048 | 0.017 |
| Mountain | 2.73 | 0.0038 | 0.139 |
| Pacific | 2.68 | 0.00051 | 0.019 |
| Alaska and Hawaii | 4.39 | 0.0012 | 0.594 |
| United States | 3.21 | 0.00023 | 0.072 |

[a] ERCO estimates.

[b] Derived from Edison Electric Institute, Statistical Yearbook 1977, pp. 34-35.

Mountain - Mont., Idaho, Wyo., Colo., N.M., Ariz., Utah, Nev.

Pacific - Wash., Ore., Cal.

## 4.4 Secondary Impacts

Plant shutdowns and the attendant job losses or production cutbacks are unlikely for this industry. A brief summary of industry impacts is shown below in Table 4-5.

A slight increase in oil imports is listed as a RCRA impact on the electic utility industry. There were 96 plants in 1977 which burned both some coal and at least 100,000 barrels of oil.[3] At the margin, the increased cost of coal waste disposal should encourage an increase in oil use. The quantity of the import increase was not modeled.

## TABLE 4-5

## SUMMARY OF IMPACTS ON THE ELECTRIC UTILITY INDUSTRY[a]

| | OPTION A | OPTION B |
|---|---|---|
| Number of generators (1978) | 750 | 750 |
| Plant shutdowns | Unlikely | Unlikely |
| Job losses | Unlikely | Unlikely |
| Production cutbacks | Unlikely | Unlikely |
| U.S. demand reduction | Small | Small |
| Price increase | Small | Small |
| Balance of payments effects | Slight import increase | Slight import increase |

[a] ERCO estimate.

## NOTES TO CHAPTER FOUR

1. Teknekron, Inc., Review of New Source Performance Standards for Coal Fired Utility Boilers, Volume II - Economic and Financial Impacts, March 1978.

2. Teknekron, Inc., 1978.

3. Annual Summary of Cost and Quality of Electric Utility Plant Fuels, 1977, Office of Electric Power Regulation, Federal Energy Regulatory Commission, U.S. Department of Energy, September 1978.

# PART II

# PULP AND PAPER MILLS

Preceding page blank

## CHAPTER FIVE

## CHARACTERIZATION OF THE PULP AND PAPER INDUSTRY

The multisegmented, multibillion-dollar paper industry produces thousands of intermediate and final products. Its 1977 sales of $40.2 billion accounted for over 3 percent of all manufacturing sales. It employs almost 1 percent of the total work force (676,000 people in 1976). It is the third largest industrial water user and the fourth largest industrial purchaser of fuel and electricity, even though it generates approximately 45 percent of its own heat and electricity.

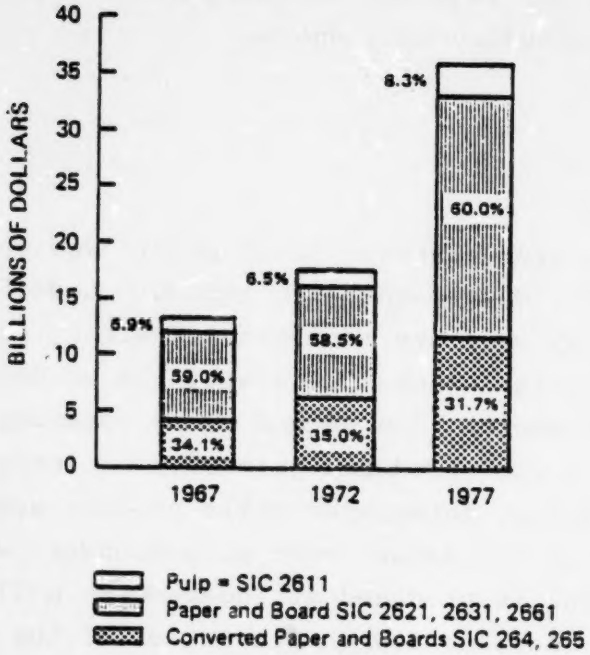
The companies in the industry are large, highly diversified establishments which produce pulp, paper, paperboard and building board (such as roofing shingles and wood fiber board) as well as maintain their own timberland, wholesaling and paper product conversion operations. The extent of the vertical integration in the paper industry renders artificial most segmentation for purposes of financial analysis since the companies report few statistics by segment other than production values. Thus figures for profitability, asset size and composition, employment productivity, and other economic characteristics for each individual segment (pulp, paper, paperboard, and building board) are largely unavailable. Approximately 72 percent of the pulp, paper, paperboard and building board production occurs in companies which are integrated in three tiers: (1) woodland control, (2) pulp manufacture, and (3) paper and board production.[1] Many of these companies, as well as

Preceding page blank

those that are not as widely integrated, also own converting operations. These facilities reduce bulk paper to more marketable sizes. This report focuses on the pulp (SIC 2611), paper (SIC 2621), paperboard (SIC 2631), and building board (SIC 2661) segments of the paper industry. Independent converting (SIC 264 and 265) establishments, which buy paper directly from the mills as an intermediate good and turn it into final products, are not included in this work. Figure 5-1 shows the relationship between the pulp, paper, and board segments and the converted paper and board segments of the industry. As the figure illustrates, the percentage of the value of industry product shipments accounted for by the converted paper and board segments has decreased since 1972.

This industry produces several large volume waste streams which will be examined in the next chapter. The waste streams are (1) wastewater treatment sludge from a number of industry segments, (2) wastes from chemical pulping operations, (3) bark wastes, (4) coal ash, and (5) secondary fiber reclamation wastes.

In the analysis that follows, each of the major industry segments is briefly described (Section 5.1, industry structure and trends are examined (Section 5.2), and financial data are reviewed (Section 5.3). Model plant data are developed in Section 5.4. The model plant analysis is organized along process lines and draws on the tables presented in Section 5.2, which show the approximate relationships between process and product.



(Bureau of the Census and BDC)

Figure 5—1. Value of pulp, paper, board, and converted products shipments. (*U.S. Industrial Outlook 1977,* U.S. Department of Commerce Domestic and International Business Administration.)

## 5.1 Size and Scope of the Pulp and Paper Industry

Each of the paper industry's major segments - pulp, paper, paperboard, and building board - are characterized below. Production sales, geographical distribution, product description and composition, and import/export data, where relevant, are included in the descriptions. A final section then discusses employment. Because there are no data on employment by industry segment, the data presented in this section treat the industry as a whole.

### 5.1.1 Pulp

There are two broad categories of pulp: wastepaper pulp and wood pulp. Wastepaper pulp and pulp made from other fibers such as rags are manufactured almost exclusively at integrated mills. These pulps will not be discussed at length in this report. The second broad category of pulp, wood pulp, is also produced primarily at integrated facilities. Currently, integrated mills produce approximately 90 percent of the annual wood pulp tonnage, while the remaining 10 percent is produced at independent mills.[2] These figures are consistent with statistics of the American Paper Institute which show that only 60 of the 279 reported wood pulp mills are operated by independent pulp companies. Table 5-1 presents a summary of wood pulp production for the last 4 years. As the table illustrates, a large portion of total wood pulp production is used captively by the producer. This is explained by the fact that the integrated mills which produce the majority of the tonnage keep 84 percent of that production for their own use. The remaining 16 percent

## TABLE 5-1

### WOOD PULP PRODUCTION
(MM short tons)[a]

| YEAR | WOOD PULP CAPACITY[b] | TOTAL PULP PRODUCTION[a] | TOTAL PULP SHIPMENTS | SIC 2611 PRODUCTION[c] | EXPORTS | IMPORTS |
|---|---|---|---|---|---|---|
| 1975 | 51.9 | 43.1 | 7.3 | 4.3 | 2.6 | 3.1 |
| 1976 | 53.1 | 48.8 | 7.9 | 5.1 | 2.6 | 3.7 |
| 1977 | 54.7 | 50.3 | NA | 5.3 | 2.8 | 3.9 |
| 1978[b] | 55.9 | 52.6 | 9.0 | 5.5 | 2.8 | 4.0 |

[a] U.S. Department of Commerce, U.S. Industrial Outlook, 1978.

[b] 1978 estimates.

[c] SIC 2611 production is also included in total pulp shipments.

is sold to domestic or foreign firms and is sometimes referred to as "market pulp."

The geographic distribution of pulp production is weighted toward the South. Approximately 64 percent of the nation's pulping capacity is located in southern states. Another 18 percent of the capacity is located in the western states while the remainder is split evenly between the eastern and the north central states.

There are two broad categories of wood pulp processes - chemical and mechanical. In chemical pulping processes, chemicals are used to separate the fibers from the lignin bonding material in wood. In mechanical pulping processes, the wood or wood chips are actually beaten or ground to break the wood into its component fibers.

Each type of pulp can be bleached or unbleached, depending on the desired quality of the paper product for which it is used. Bleached pulp produces a whiter, higher quality paper. However, the bleaching process also adds more chemicals to the pulping liquors.

Table 5-2 shows total pulping capacity broken down by pulp type, excluding wastepaper pulp, as well as the approximate fraction of each pulp type which is bleached. The table shows that total wood pulp capacity increased only slightly between 1972 and 1975 and expanded more rapidly between 1975 and 1977. Table 5-3 shows the approximate end uses of each kind of pulp.[4] Pulps in various combinations are used to manufacture different paper products, as described in Sections 5.2.2 through 5.2.4 below.

Neither exports nor imports of pulp amount to more than 1 percent of total pulp production. Overall, the industry is a net importer.[5] Exports total approximately 3 million short tons a year whereas annual imports, mostly Canadian pulp, come to about 4 million tons. Table 5-1 provides recent pulp import-export figures.

### 5.1.2 Paper

Establishments which are primarily engaged in paper manufacture are classified under SIC 2621. However, in the paper segment, as was the case in the pulp section of the industry, the segmentation is not precise; most companies produce paperboard and pulp as well as paper. Thus the

## TABLE 5-2

## PULP CAPACITY BY TYPE
(MM short tons)[a]

| PULP | 1972 | 1975 | 1977 | % BLEACHED[b] |
|---|---|---|---|---|
| Wood pulp | | | | |
| Chemical Pulp | | | | |
| Dissolving and special alpha | 1.7 | 1.7 | 1.6 | 100 |
| Sulphite | 2.4 | 2.4 | 2.3 | 81 |
| Sulphate (Kraft) and soda | 32.8 | 35.0 | 37.2 | 42[c] |
| Semi-chemical | 3.9 | 4.2 | 4.6 | 8 |
| Mechanical Pulp | | | | |
| Stone ground wood and refined | 4.6 | 4.6 | 4.6 | 25[d] |
| Thermo mechanical | - | 0.1 | 0.5 | NA |
| Defribated and exploded (building paper pulp) | 3.1 | 3.7 | 3.8 | 0 |
| Total wood pulp[e] | 50.7 | 51.7 | 54.6 | 35 |

---

[a] American Paper Institute, Statistics of Paper and Paperboard.

[b] Average since 1972, including 1978-79 estimates.

[c] An additional 4 percent of total sulphate is semi-bleached.

[d] Average 1966-71. This category is no longer reported as bleached or unbleached.

[e] May not add to totals on Table 5-1 because of rounding.

## TABLE 5-3

## DISTRIBUTION OF PULP TYPES ACROSS END USES[a,b]

## (PERCENTAGE OF EACH TYPE OF PULP BY GRADE OF PAPER AND BOARD)

| PULP | TOTAL[c] (%) | PRINTING AND WRITING PAPER | | | | | INDUSTRIAL PAPERS | | |
|---|---|---|---|---|---|---|---|---|---|
| | | NEWS-PRINT | UNCOATED GROUND-WOOD | COATED GROUND-WOOD | UNCOATED FREE SHEET | THIN | UNBLEACHED | BLEACHED | SPECIALTY |
| Dissolving[d] | 100 | - | - | 4 | 34 | 2 | - | 10 | 30 |
| Bleached sulphite | 100 | 1 | 2 | 9 | 34 | 2 | - | 4 | 3 |
| Unbleached sulphite | 100 | 30 | 20 | 12 | 7 | 1 | - | 5 | 1 |
| Bleached and semi-bleached sulphate | 100 | 5 | 1 | 12 | 23 | 1 | 2 | 7 | 2 |
| Unbleached sulphate | 100 | *[f] | * | * | 1 | * | 21 | 1 | 1 |
| Groundwood | 100 | 43 | 22 | 12 | 1 | * | * | - | * |
| Semi-chemical | 100 | 1 | * | 1 | 7 | 1 | * | * | * |
| Soda and other | 100 | 1 | * | 5 | 15 | 1 | * | * | * |
| Wastepaper pulp | 100 | 3 | * | 2 | 4 | * | 1 | * | 1 |
| Other fibrous material | 100 | 1 | 1 | * | 11 | 1 | - | * | 20 |
| Total pulp production (MM short tons) | NA | 3.6 | 1.5 | 3.3 | 6.2 | 0.34 | 4.2 | 1.3 | 0.8 |
| Total paperboard production[e] (MM short tons) | NA | 3.4 | 1.4 | 3.8 | 6.5 | 0.35 | 4.0 | 1.3 | 0.56 |

---

[a] Fibers as a Renewable Resource, National Research Council, API restructured data, 1973.

[b] Approximate distribution only. Distribution will vary with processes, prices, and trends in final product demand.

[c] May not total to 100 because of rounding.

[d] Much of the dissolving pulp is used for nonpaper industry applications (such as rayon acetate fibers and cellulosic chemicals), which are not shown here.

[e] May not be equivalent to other product category totals shown in other tables because this is restructured data.

[f] * = Less than 0.5 percent.

## TABLE 5-3 (CONT.)

| PULP | TISSUE | BLEACHED BRISTOLS | BLEACHED PACKAGING | UNBLEACHED PAPERBOARD | SEMI-CHEMICAL PAPERBOARD | RECYCLED PAPERBOARD | BUILDING PAPER AND BOARD | TOTAL PULP PRODUCTON (MM SHORT TONS) |
|---|---|---|---|---|---|---|---|---|
| Dissolving[d] | 6 | - | - | - | - | 14 | - | 0.05 |
| Bleached sulphite | 39 | 1 | 2 | 0.5 | - | 1 | 0.5 | 2.12 |
| Unbleached sulphite | 12 | 1 | 1 | 2 | - | 6 | 2 | 0.49 |
| Bleached and semi-bleached sulphate | 10 | 7 | 24 | 4 | - | 2 | * | 16.2 |
| Unbleached sulphate | 1 | *[f] | * | 71 | 2 | 1 | * | 17.9 |
| Groundwood | 3 | - | 1 | - | 1 | 2 | 15 | 5 |
| Semi-chemical | 2 | - | 1 | - | 76 | * | 9 | 3.9 |
| Soda and other | 2 | - | 1 | 5 | - | 1 | 69 | 3.2 |
| Wastepaper pulp | 8 | - | - | 3 | 7 | 60 | 9 | 14 |
| Other fibrous material | 6 | - | 27 | - | - | 7 | 50 | 0.63 |
| Total pulp production (MM short tons) | 4.3 | 1.3 | 4.1 | 14.0 | 4.3 | 9.1 | 5.0 | 63.4 |
| Total paperboard production[e] (MM short tons) | 4.0 | 1.3 | 3.9 | 13.7 | 4.3 | 7.9 | 5.6 | NA |

---

[d] Much of the dissolving pulp is used for nonpaper industry applications (such as rayon acetate fibers and cellulosic chemicals), which are not shown here.

[e] May not be equivalent to other product category totals shown in other tables because this is restructured data.

[f] * = Less than 0.5 percent.

figures which follow may not refer exclusively to SIC 2621 firms.

Shipments of each major paper product are shown in Table 5-4. Shipments have been growing slowly throughout the seventies, although they declined in the recession of 1975 along with the output of most other paper industry segments. The contribution to the total U.S. paper market of each major product is displayed in Table 5-5. Printing and writing papers, which include book, magazine, office,

TABLE 5-4

PAPER SHIPMENTS BY MAJOR PRODUCT
(MM short tons)[a]

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|---|---|---|
| Newsprint | 3.5 | 3.5 | 3.7 | 3.7 | 3.6 | 3.7 | 3.7 |
| Printing & writing papers | 11.0 | 11.2 | 12.2 | 13.4 | 13.5 | 11.0 | 13.1 |
| Unbleached kraft | 3.7 | 3.7 | 3.8 | 3.9 | 4.1 | 3.3 | 3.8 |
| Bleached packaging papers | 1.1 | 1.2 | 1.2 | 1.1 | 1.1 | 0.9 | 1.0 |
| Tissue paper-including sanitary stock | 3.7 | 3.8 | 4.0 | 4.0 | 4.1 | 4.0 | 4.2 |
| Special industrial papers | 0.4 | 0.4 | 0.5 | 0.6 | 0.6 | 0.4 | 0.6 |
| Total | 23.4 | 23.8 | 25.4 | 26.7 | 27.0 | 23.3 | 26.4 |

[a] American Paper Institute, Statistics of Paper and Paperboard, 1977.

### TABLE 5-5

### U.S. PAPER PRODUCTION, PERCENTAGE CONTRIBUTION OF MAJOR PAPER PRODUCTS[a]

| | PAPER PRODUCTION BY PRODUCT (%) |
|---|---|
| Printing & writing papers | 48 |
| Newsprint | 14 |
| Unbleached kraft | 15 |
| Bleached packaging papers | 5 |
| Tissue paper | 16 |
| Special industrial paper | 2 |
| Total | 100 |

[a] American Paper Institute, *Statistics of Paper and Paperboard, 1977*.

bond, mimeograph, and envelope papers, and bleached bristols (index, file folder, and postcard paper), account for 48 percent of the market. Tissue paper, which includes waxing and wrapping tissue stock as well as sanitary products like toilet and facial tissues, is the next single largest paper product category accounting for 16 percent of the total paper output. Newsprint and unbleached kraft, the source of most wrapping, bag, and sack paper, each represent approximately 15 percent of the country's paper production. However, the United States imports nearly twice as much newsprint as the domestic paper industry produces.

Nearly half the pulp used for paper production is bleached or semi-bleached sulphate (kraft pulp). Groundwood, used primarily for newsprint, and unbleached kraft are the next most widely used pulps, acccounting for 13 and 15 percent of total paper production respectively. More than 75 percent of the total paper is produced from chemical pulping processes, and 97 percent is manufactured from virgin fibers.

There are approximately 350 to 360 paper mills in the United States.[6] There is some variance in the number of mills reported by different sources due to differing opinions on how to distinguish mills from mill complexes. Each of the large companies owns several mills. The approximate number of firms producing each of the major paper products is shown in Table 5-6. Since many companies manufacture paper in several of the product categories, the total number of firms cannot be totaled to derive an industry-wide company count.

TABLE 5-6

APPROXIMATE NUMBER OF FIRMS PRODUCING MAJOR PAPER PRODUCTS, 1975[a]

| PAPER PRODUCT | NO. OF FIRMS |
|---|---|
| Newsprint | 14 |
| Printing and writing paper | 71 |
| Uncoated groundwood | 20 |
| Unbleached kraft | 28 |
| Bleached boards and bristols | 26 |
| Bleached packaging paper | 40 |
| Specialty paper | 51 |
| Tissue | 51 |

[a] Arthur D. Little, Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations, EPA, May 1977.

As for pulp production, the bulk of the capacity is found in the south. During the 1930's paper companies migrated south and west from the north and east to take advantage of cheaper fossil fuel and labor, lower initial construction costs, and favorable timberland purchases from lumber companies that failed during the depression. Because of this movement, the older, smaller, often nonintegrated, and usually less productive mills are generally found in the northeast and north central United States while the newer larger, widely integrated plants are located in the south and Pacific northwest.[7]

### 5.1.3 Paperboard

Mills producing primarily paperboard are classified as SIC 2621. In 1972, there were 95 establishments attributed to this segment of the paper industry.[8] Data on paperboard shipments, by major product, are presented in Table 5-7. As the table illustrates, paperboard shipments were 28.4 million short tons in 1976, up from 24.8 million in 1975, but not equaling the industry record of 29.6 million achieved in 1973, although it should be noted that these production figures may include tonnage manufactured at mills not classified in SIC 2621.[9] Approximately 7 percent of this total production is shipped out of the country, making the sector a net exporter.

Unbleached sulphate (kraft) and wastepaper are the pulps most widely used for paperboard manufacture. Bleached kraft is the dominant component in packaging products for which cleanliness, aesthetics, and high strength-to-weight relationships are important. For example, all paperboard used for milk and food service containers are bleached kraft.

## TABLE 5-7

## PAPERBOARD SHIPMENTS BY MAJOR PRODUCT
(MM short tons)[a]

| PRODUCT | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|---|---|---|
| Containerboard[b] | 14.0 | 14.3 | 16.0 | 16.9 | 16.8 | 14.6 | 16.7 |
| Linerboard | 9.4 | 9.5 | 10.9 | 11.4 | 11.3 | 9.9 | 11.4 |
| Corrugating material | 4.3 | 4.5 | 4.8 | 5.3 | 5.2 | 4.4 | 5.1 |
| Chip and fillerboards | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Boxboard[b] | 6.2 | 6.2 | 6.6 | 6.8 | 6.4 | 5.7 | 6.6 |
| Folding | 4.1 | 4.1 | 4.1 | 4.7 | 4.4 | 3.9 | 4.7 |
| Setup | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 | 0.3 | 0.3 |
| Milk carton and food service | 1.7 | 1.6 | 1.7 | 1.6 | 1.6 | 1.5 | 1.5 |
| Other[b] | 5.0 | 5.4 | 5.9 | 5.9 | 5.7 | 4.6 | 5.2 |
| Gypsum wallboard facing | 0.7 | 0.9 | 1.0 | 1.1 | 1.0 | 0.9 | 1.0 |
| Tube, can, and drum | 0.8 | 0.9 | 1.1 | 1.1 | 1.1 | 0.9 | 1.0 |
| Exports | 1.9 | 2.1 | 2.2 | 2.0 | 2.1 | 1.5 | 1.7 |
| Unspecified | 1.6 | 1.5 | 1.6 | 1.7 | 1.5 | 1.3 | 1.5 |
| Total[b] | 25.4 | 26.0 | 28.5 | 29.6 | 28.9 | 24.8 | 28.4 |

[a] American Paper Institute, Statistics of Paper and Paperboard, 1977.

[b] May not total exactly because of rounding.

Federal regulations require that those cartons which come into direct contact with wet food products be made of virgin material. For packaging applications like cereal and cracker boxes where an inner lining is used or where low cost is important like soap and detergent packaging, recycled paperboard dominates.[10] Nearly 70 percent of all exports are made from unbleached kraft, most of it linerboard.

### 5.1.4 Building Board

The building board segment, SIC 2661, is the smallest in the paper industry. Throughout the seventies, building board production has averaged 9 percent of industry-wide production. There are three major product categories in this segment: construction paper, insulation board, and pressed wood fiber board (hardboard). Gypsum wallboard is not included in this industry segment; although used primarily for building, gypsum wallboard is classified as a paperboard. For effluent guideline development, the EPA has included both insulation board and hardboard in the wood products industry (SIC 24). But for the purpose of hazardous waste regulations, they will be covered here in the building board segments of the pulp and paper industry. Apparently insulation board and boxboard share both effluent loading and market characteristics with the other lumber products.[11] For the purposes of this description, all three major products will be considered.

Building board production is fairly evenly divided between the three major products. During the seventies construction paper and hardboard production accounted for 35 and 37 percent of the total, whereas insulation board represented approximately 28 percent (Table 5-8).

## TABLE 5-8

## BUILDING BOARD PRODUCTION

## (MM short tons)[a]

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | % OF TOTAL PRODUCTION 1976 |
|---|---|---|---|---|---|---|---|---|
| Construction paper | 1.594 | 1.837 | 1.916 | 1.856 | 1.845 | 1.616 | 1.832 | 35 |
| Insulation board | 1.219 | 1.446 | 1.529 | 1.547 | 1.295 | 1.249 | 1.441 | 28 |
| Hardboard | 1.463 | 1.718 | 1.908 | 2.001 | 1.978 | 1.784 | 2.145 | 37 |
| Total | 4.276 | 5.001 | 5.353 | 5.404 | 5.118 | 4.649 | 5.418 | 100 |

[a] American Paper Institute, *Statistics of Paper and Paperboard, 1977*, Department of Commerce data.

The demand fot building board is more closely associated with the demand for construction material than the demand for paper. As with all building materials, the demand for building board divides into two components: (1) new demand and (2) replacement demand. In the construction paper segment, the demand is less cyclical than the demand for all building materials because there is a large replacement component. Roofing shingles are the largest end use of construction paper and they require frequent replacement.[13]

### 5.1.5 Industry Employment

The pulp and paper industry is dominated by large firms. The typical firm owns several mills which produce different types of pulp, paper, and board, often in different states. Table 5-9 shows the distribution of establishments in the industry by plant type and number of employees. The table shows that overall, more than half of all facilities in excess of 100 employees and less than one-fith had less than 20 employees. Only in pulp production do small mills comprise the largest segment, while medium size plants with 20 to 99 employees dominate the building board segment.

## 5.2 Industry and Market Analysis for the Pulp and Paper Industry

Established in the United States during the 1880's, the paper industry is a mature industry, dominated by large firms which have significant market power in certain industry segments. These characteristics can be seen in the

## TABLE 5-9

## PULP, PAPER, AND BOARD MILLS, NUMBER OF EMPLOYEES PER ESTABLISHMENT (1972)[a]

| | | | PAPER | | PAPERBOARD | | BUILDING BOARD | |
|---|---|---|---|---|---|---|---|---|
| # EMPLOYEES/ ESTABLISHMENTS | TOTAL # ESTABLISHMENTS | PULP # ESTABLISHMENTS | # ESTABLISHMENTS | % INTEGRATED WITH PULP MILL | # ESTABLISHMENTS | % INTEGRATED WITH PULP MILL | # ESTABLISHMENTS | % INTEGRATED WITH PULP MILL |
| 16 1-19 | 122 | 25 | 54 | - | 25 | - | 18 | 5 |
| 28 20-99 | 215 | 13 | 64 | 23 | 90 | - | 48 | 40 |
| 56 > 100 | 437 | 22 | 231 | 59 | 158 | 49 | 26 | 81 |
| Total | 774 | 60 | 349 | 44 | 273 | 29 | 92 | 45 |

[a] Department of Commerce, Bureau of the Census 1972 Census of Manufacturers.

industry's structure (Section 5.2.1), conduct and performance (Section 5.2.2).

### 5.2.1 Industry Structure

There are at least 775 pulp, paper, and board mills owned by approximately 400 companies (counting contiguous mills as one unit, there are 561 mill complexes).[14] As a whole, the paper industry appears to have a low concentration ratio; the 10 largest firms account for less than 36 percent of total capacity. In other large manufacturing industries, such as chemical, petroleum, and steel, 10 or fewer firms typically represent more than 50 percent of capacity. However, the 15 largest pulp and paper companies recorded 57 percent of total industry sales.[15] Furthermore, the capacity concentration ratios in each product category are much higher than the overall industry figure. The product categories listed in Table 5-10 represent over 85 percent of 1977 paper and board capacity. In 10 of these 14 categories, the top eight firms own over 50 percent of total capacity. Most notable are the dissolving pulp, uncoated groundwood, tissue, and construction paper segments where the top eight companies account for over 75 percent of total capacity. In the dissolving pulp segment, one firm alone accounts for 44 percent of capacity.[16]

On the other hand, several segments have more competitive qualities. The recycled paperboard and printing sector as well as the writing paper sectors, for example, both contain many firms and relatively low concentration ratios at the eight company level. However, the pattern of finding higher concentration ratios in smaller product categories repeats in the printing and writing segment. For

## TABLE 5-10

## PAPER INDUSTRY CONCENTRATION STATISTICS - MAJOR PAPER AND BOARD PRODUCTS, 1975[a]

| PRODUCT | PERCENT OF U.S. CAPACITY | | APPROXIMATE NO. OF FIRMS |
|---|---|---|---|
| | TOP 4 FIRMS | TOP 8 FIRMS | |
| Market pulp | | | |
| Bleached paper grade | 30.9 | 50.5 | 25 |
| Dissolving | 77.0 | 100.0 | 8 |
| Paper | | | |
| Newsprint | 44.0 | 64.5 | 14 |
| Printing & writing | 26.1 | 42.1 | 71 |
| Uncoated groundwood | 65.2 | 84.8 | 20 |
| Bleached packaging paper | 36.4 | 49.9 | 40 |
| Unbleached kraft | NA | 69.4 | 28 |
| Special industrial paper | 25.7 | 42.1 | 51 |
| Tissue | 55.8 | 77.6 | 51 |
| Paperboard | | | |
| Unbleached kraft linerboard | 34.8 | 57.0 | 28 |
| Corrugating material | 27.8 | 46.2 | 29 |
| Recycled paperboard | 23.3 | 38.2 | 101 |
| Bleached board & bristols[b] | 44.9 | 67.1 | 26 |
| Building board | | | |
| Construction paper | 57.7 | 81.0 | 23 |

[a] Arthur D. Little, Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations, Volume II, for U.S. Environmental Protection Agency, May 1977.

[b] Bleached board (a paperboard product) and bristols (a paper product) are grouped together here because they are produced in the same mills, in some cases by interchangeable machines.

example, the top eight firms which produce uncoated groundwood, one type of printing and writing paper, account for nearly 85 percent of total capacity.

The degree of vertical integration in the industry is also high. As discussed in Section 5.1, approximately 72 percent of the pulp, paper, and board production is shipped by companies which are integrated to woodland management, pulp manufacture, and paper and board production. In addition, many firms own their own converting operations. Tissue and building board companies are almost always integrated to the converting level.

Because such a large degree of integration is required to compete with the industry leaders and, as described below, growth in demand is declining, there are high barriers to entry in the paper industry. In fact, there have been no new grassroot entrants in recent years. All new paper industry participants entered through merger or acquisition.[17]

Thus, when individual product categories are examined, the paper industry appears to be composed of widely integrated, relatively highly concentrated segments in which oligopolistic behavior is possible. However, supply and demand conditions which exist in this mature industry determine how much market power can be exercised, as discussed briefly below.

### 5.2.2 Industry Conduct and Performance

In this section, a number of industry and market characteristics are described. Price trends and market conditions for the industry as a whole and for the principal segments are discussed. Much of the information presented here is derived from a previous study of the industry.[18]

During the 1960's and early 1970's, cycles of excess capacity and increasing productivity kept paper price increases slightly below average price rises among other commodities (see Figure 5-2). The new capacity added during this period led to oversupply and kept prices down as producers tried to increase their market share. Starting in 1973, price pressures eased and the industry was able to pass on their accumulated cost increases as product demand strengthened. The overall paper price index increased by 34 percent compared to the 27 percent rise observed in the wholesale price index.

Although there are few, if any, new markets for the paper industry to develop, it faces relatively little competition from other industries. For example, there are few substitutes for most printing and writing, tissue, and building board products. However, packaging papers and paperboards are experiencing some competition from plastics. Price elasticities, where available, reflect these observations. Paper demand as a whole is relatively insensitive to price changes. All segments have price elasticities in the relatively inelastic range between 0.20 and 1.0. Printing and writing papers have the lowest industry price elasticity (approximately 0.22), whereas unbleached kraft packaging papers, which experience competition from plastics, have the highest industry price elasticity (0.9, which is, however, still in the inelastic range).

In general, those sectors facing the most serious competitive threats and highest price elasticities have experienced the slowest expansion in production during the

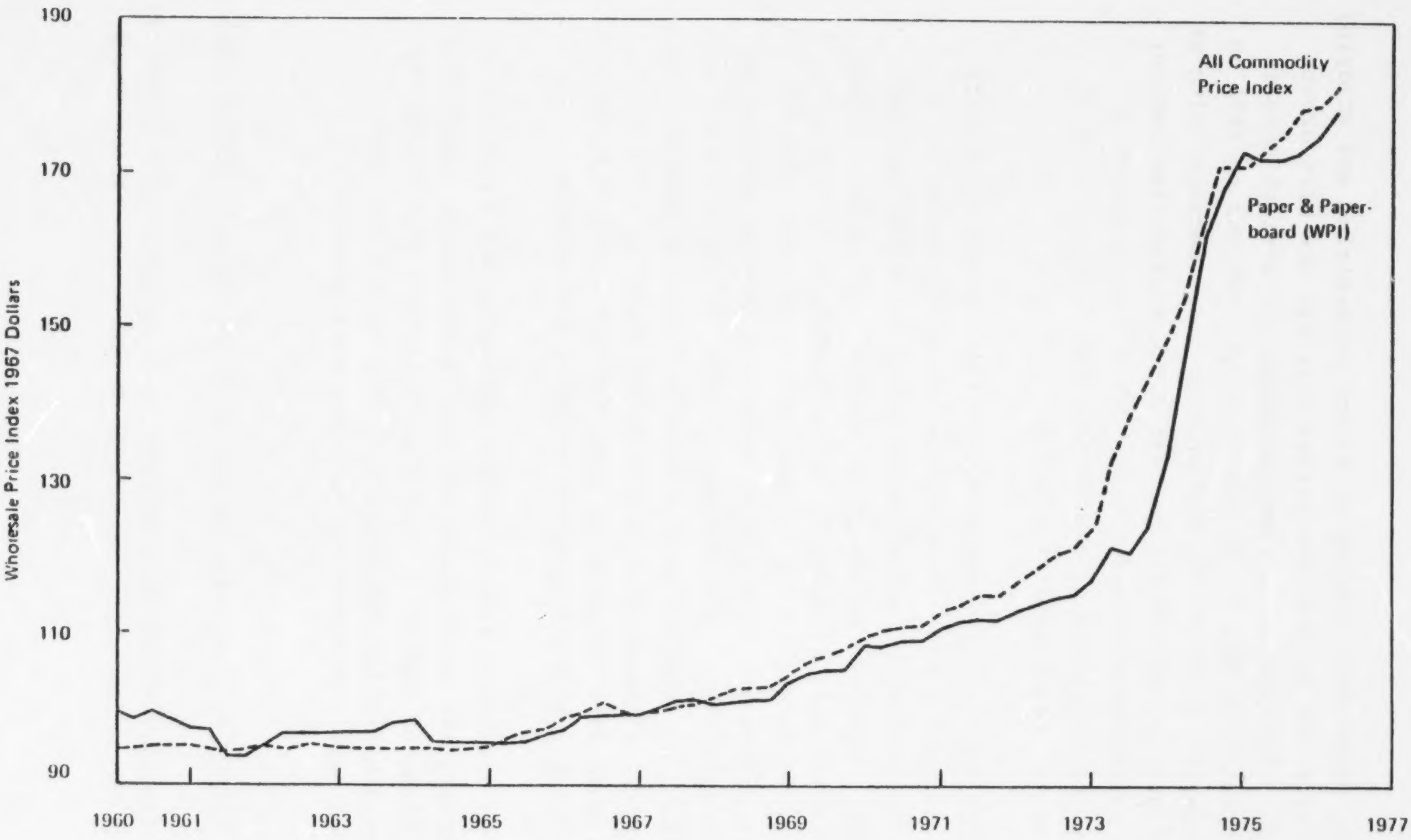


Figure 5–2. Paper and paperboard wholesale price index (WPI) and all commodity price index. (U.S. Department of Laber, *Wholesale Price Index*, 1977.)

1970's, while those facing no direct competition and enjoying relatively low price elasticities have had the best growth records. The packaging paper segments had average annual growth rates of from -1 percent to 1 percent during 1970 to 1976 whereas the printing and writing paper segment, with an annual growth rate of 3.5 percent for the same time period, faced better market conditions. Table 5-11 contains a summary of competition, elasticity, and growth trends in each of the major product sectors.

Considering the competitive threat, price elasticity, and growth rate experience of the different segments, a rough evaluation of potential economic vulnerability can be made. Bleached market pulp, special industrial paper, unbleached kraft linerboard, and corrugating material, probably have the lowest economic vulnerability. Both market pulp and linerboard enjoy strong foreign as well as domestic markets. The industrial paper market is small and specialized enough to keep favorable market prospects. Similarly, although linerboard and corrugating material experience some competition from plastics, they are still the lowest cost materials for shipping containers.

On the other hand, bleached packaging and recycled paperboard are potentially the most economically vulnerable. Both bleached packaging papers and recycled paperboard are facing substantial competition from plastics and both sectors have experienced persistent overcapacity.

## 5.3 Financial Characterization of the Pulp and Paper Industry

The purpose of this section is to describe the financial structure of the paper industry. Financial characteristics

## TABLE 5-11

## SUMMARY OF COMPETITION AND PRICE ELASTICITY, AND CLOSURE TRENDS IN THE PAPER INDUSTRY

| PRODUCT | COMPETITIVE THREATS |  | PRICE ELASTICITY[a] | PRODUCTION GROWTH RATE 1970-76(%) | EXPECTED ANNUAL CAPACITY GROWTH RATE 1977-79 (%) | ROUGH POTENTIAL ECONOMIC VULNER-ABILITY[c] |
|---|---|---|---|---|---|---|
|  | FROM INSIDE INDUSTRY[a] | FROM OUTSIDE INDUSTRY[a] |  |  |  |  |
| Market pulp |  |  |  |  |  |  |
| Bleached paper grade | Insignificant | None | 0.46±0.35 | 5.0[a] | 2.3[b] | Low |
| Dissolving | None | Decreased demand for end products | 0.63±0.32 | 1.0[a] | 0.1 | Some |
| Paper |  |  |  |  |  |  |
| Newsprint | Insignificant | TV and radio | 0.22±0.09 | 1.3 | 1.5 | Low |
| Printing & writing | Competition among grades, i.e., coated replaced uncoated papers | Insignificant | 0.26±0.14 | 3.5 | 2.8 | Some |
| Uncoated groundwood | Some chemical pulps | Insignificant | NA | 3.1 | 0.11[b] | Low |
| Bleached packaging | Some unbleached packaging | Plastic | NA | -1.05 | 0.6[b] | High |
| Unbleached kraft | Some bleached packaging | Plastic | 0.90±0.26 | 0.98 | 0.3 | Some |
| Special industrial | Insignificant | Substitute products | NA | 7.5 | 1.1[b] | Low |
| Tissue | None | Nonsanitary - plastic film & foil | 0.45±0.18 | 2.17 | 1.8 | Slow |
| Paperboard |  |  |  |  |  |  |
| Unbleached kraft | Recycled | Plastic | 0.50±0.27 | 3.7 | 2.8[b] | Low |
| Corrugating material | Insignificant | Heavy gauge shrink plastic | 0.35±0.09 | 3.5 | 2.7 | Low |
| Recycled paperboard | Bleached kraft | Boxboard - plastic "bubble" packaging | 0.46±0.35 | 1.0 | 1.4 | High |
| Bleached board & bristols | Some unbleached board | Bristols - computer tape & internal computer memories | NA | 2.8 | 2.8 | Some |
| Gypsum wallboard | Insignificant | Paneling alternatives | NA | 7.0 | 0.6[b] | Some |
| Building board |  |  |  |  |  |  |
| Construction paper | Insignificant | Vinyl floor tile and wall-to-wall carpeting both reduce need for underlayment paper | NA | 1.5[a] | 0.19[b] | Some |

[a] Arthur D. Little data.

[b] Total sulphate and soda expansion used as a proxy for market pulp expansion (API data).

[c] ERCO estimates.

will vary from segment to segment as well as by the size of the firm within each segment. As mentioned above, however, it is difficult to analyze the financial characteristics of individual industry segments because most paper industy statistics are reported only in aggregate form. Therefore, the financial characteristics of the industry as a whole will be presented.

Industry profits were below average profits for other manufacturing industries during the 1960's and 1970's. Industry net profits as a percent of sales fell to below 3 percent. The paper industry experienced record profit lows in 1970 to 1972 because of the overcapacity problems and because it was impossible to pass on the rising costs of raw materials, energy, and labor in the weak early markets of the 1970's. However, as demand improved in 1973 to 1974, capacity expansion slowed, price increases became possible, and profits improved to a post-World War II high in 1974. Although the recession in late 1974 and 1975 caused a downturn in profits again, most prices held and profits are expected to improve as the economy recovers.[20]

The paper industry is quite capital intensive. Its sales to asset ratio is 1.14, which makes it the fifth most capital intensive among all U.S. manufacturing industries. A look at the industry's cost of operations reveals that its labor bill is approximately 28 percent of total operating costs; materials account for 61 percent and energy costs another 10 percent.[21]

At the present time, the capital structure in the industry shows a high proportion of debt. In 1976, debt was 31 percent of total capital, and the debt/equity ratio was 44 percent.[22] During the 1960's, when the industry was in a period of capital expansion, the capital structure experienced a rapid displacement of equity financing by long term debt. By 1970 to 1971, the debt to total capital ratio had reached 33 percent and low profitability exhausted the borrowing power of many firms. Both the low profits and high debt ratios contributed to the slower rate of capacity expansion experienced in the 1970's, as noted earlier. The high debt levels and the inflation of capital goods during the 1970's prevented many companies from using debt to finance major expansions even as profitability rose between 1972 and 1974.[23]

Since the 1960's, most capital project funds have come from retained earnings, as shown in Table 5-12. Stock issues were important only in 1961, 1969, and 1971. However, these trends seem to be changing. Although retained earnings are still the major source of funds, both new stock sales and additions to long term debt increased in 1974-75.

Overall, at the present time, the paper industry has both a reasonable cash flow situation and the ability to raise funds for capacity expansion. However, to fully assess the impact of required hazardous waste control spending, we turn next to model plant analyses.

## 5.4 Model Plant Descriptions

The average and worse case model plants used here are selected from the plants modeled in the 1977 Arthur D. Little study. ADL developed a total of 34 model plants manufacturing 13 major paper products from a variety of fiber furnishers. The models represent plant sizes typical for a given product which operate at design capacity.

TABLE 5-12

## CHANGES IN PAPER AND ALLIED PRODUCTS INDUSTRY CAPITAL STRUCTURE, 1970-75 ($MM)[a]

| YEAR | NET CHANGE IN EQUITY<br>RETAINED EARNINGS[b] | NET STOCK SALES | TOTAL | NET CHANGE IN LONG-TERM DEBT |
|---|---|---|---|---|
| 1960 | 275 | 39 | 314 | 110 |
| 1961 | 255 | 401 | 656 | 97 |
| 1962 | 288 | (134) | 154 | 234 |
| 1963 | 286 | (171) | 115 | 9 |
| 1964 | 378 | 40 | 418 | 3 |
| 1965 | 461 | (93) | 368 | 472 |
| 1966 | 539 | 6 | 545 | 657 |
| 1967 | 405 | (104) | 301 | 632 |
| 1968 | 493 | (201) | 292 | 463 |
| 1969 | 569 | 340 | 909 | 68 |
| 1970 | 289 | (196) | 93 | 555 |
| 1971 | 94 | 253 | 347 | 417 |
| 1972 | 564 | (275) | 289 | (164) |
| 1973 | 1,025 | (104) | 921 | 100 |
| 1974 | 1,668 | 124 | 1,792 | 411 |
| 1975 | 1,158 | 118 | 1,276 | 736 |
| Totals | 8,747 | 43 | 8,790 | 4,800 |
| % of total capital | | | 65% | 35% |

---

[a] Arthur D. Little, Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations, EPA, May 1977.

[b] Net profit retained in business.

Models refer to new mill installations typical of good technical practice in 1974. The plants are based on the use of a single paper machine. The same amount of product could be made on two or more smaller machines at significantly different cost. Hence, while the model plants embody one set of typical conditions, different and equally valid assumptions could be made to represent other conditions.

Two plants were selected for the analyses of RCRA impacts. The model plant is an unbleached kraft linerboard mill. Unbleached kraft linerboard is the industry's largest single homogeneous product line, accounting for 10,318,000 MT in 1976, or 40 percent of all paperboard manufactured and 19 percent of all industry production.[25]

The "worst-case" plant is a 100 percent recycled fiber folding boxboard mill. This plant was chosen as the worst case for several reasons. Folding boxboard is one of the industry's basic products, accounting for 4,276,000 MT in 1976, 17 percent of paperboard production and 8 percent of industry output.[26] Slightly over half of folding boxboard is made from secondary fiber. The solid wastes generated from mills using secondary fiber are typically much larger than for virgin fiber operations since between 10 and 15 percent of the raw material must be rejected in the course of manufacturing an acceptable final product.

A major factor contributing to their "worst-case" status is their present relatively weak economic position. During the last 20 years, major inroads into markets formerly supplied by recycled boxboard have been made. Solid (virgin) boxboard grades now account for half the boxboard market. The inroads have been led by the appearance of solid bleached board which, though more expensive, has made major penetrations into the markets for packaging of foods, drugs, cosmetics, and toys, where appearance and high strength are important.[27] As a result, demand for recycled boxboard has yet to surpass the record tonnage produced in 1966.

In summary, the choice of unbleached kraft linerboard is the average process and product is based simply on its salience as the industry's dominant product. The choice of recycled folding boxboard is based on factors higher than average solid waste loads, economic vulnerability of the small mill sizes, and secular market erosion.

The model plants are summarized in Tables 5-13 and 5-14.

## TABLE 5-13

## MODEL PLANT CHARACTERISTICS

| | |
|---|---|
| Plant data: | |
| Product: | linerboard from virgin fiber |
| Process: | unbleached kraft |
| Mill size: | 910 metric tons per day |
| Operating days/yr: | 346 |
| Location: | southeast |
| Income data ($000): | |
| Sales: | 70,900 |
| Cost of operations: | 52,700 |
| Pretax net income: | 18,200 |

[a] ERCO estimate derived by updating model plants descriptions developed by Arthur D. Little, *Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations*, EPA, May 1977.

## TABLE 5-14

## MODEL PLANT CHARACTERISTICS

| | |
|---|---|
| Plant data: | |
| Product: | folding boxboard (secondary fiber) |
| Process: | secondary fiber repulping |
| Mill size: | 360 metric tons per day |
| Operating days/yr: | 330 |
| Location: | north central United States |
| Income data ($000): | |
| Sales: | 44,500 |
| Cost of operations: | 27,200 |
| Pretax net income: | 17,300 |

[a] ERCO estimate derived by updating model plants descriptions developed by Arthur D. Little, *Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations*, EPA, May 1977.

# NOTES TO CHAPTER FIVE

1. Arthur D. Little (ADL), *Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations,* Vol. 1, May 1977, p. 19.

2. United States Department of Commerce, *U.S. Industrial Outlook (USIO) 1978*, January 1978, pp. 40-41.

3. American Paper Institute, *Statistics of Paper and Paperboard 1977*, New York, New York, p. 24.

4. The distribution of pulps among end products is only a rough approximation. Pulps are substituted as prices, processes, and trends in final product usage changeover time.

5. Department of Commerce, *USIO 1978*, p. 41.

6. ADL, *Economic Impacts*, Vol.1, p. 22.

7. ADL, *Economic Impacts*, Vol 1, p. 28-29.

8. ADL, *Economic Impacts*, Vol.1, p. 22.

9. API, *Statistics*, p. 15.

10. Arthur D. Little (ADL), *Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations*, Vol. 2, May 1977, pp. 70-72.

11. ADL, *Economic Impacts*, Vol. 2, p. 42.

12. ADL, *Economic Impacts*, Vol. 2, p. 42.

13. ADL, *Economic Impacts*, Vol. 2, p. 42.

14. Department of Commerce, Bureau of the Census, *1972 Census of Manufacturers*.

15. Meta Systems Inc., *Qualitative Assessment of Pulp and Paper Industry Subcategories* (for EPA), March 1978, p. 3.

16. ADL, *Economic Impacts*, Vol. 1, p. 24.

17. ADL, *Economic Impacts*, Vol. 1, p. 27.

18. ADL, *Economic Impacts*.

19. ADL, Economic Impacts, Vol. 1, p. 42.

20. ADL, Economic Impacts, Vol. 1, p. 44.

21. ADL, Economic Impacts, Vol. 1, p. 19.

22. API, Statistics, p. 27.

23. ADL, Economic Impacts, Vol. 1, p. 45.

24. ADL, Economc Impacts, Vol. 1, p. 45.

25. Vance Publishing, Lockwood's Directory of the Paper and Allied Trades, 102nd ed., 1978, p. 3.

26. Vance Publishing, Lockwood Directory of the Paper and Allied Trades.

27. ADL, Economic Impacts, Vol. II, p. 36.

## CHAPTER SIX

# HAZARDOUS WASTE GENERATION IN THE PULP AND PAPER INDUSTRY

### 6.1 Issues in the Definition of Hazardous Waste Streams

The major solid waste streams of the pulp and paper industry are: (1) wastewater treatment sludge, (2) bark and hog fuel wastes, (3) coal and bark ash, and (4) wastepaper reclamation wastes. Additional small volume waste streams include certain wastes from kraft pulping operations. Of these waste streams, several exhibit leachate characteristics which are sufficiently variable as to make their proper classification (i.e., as a hazardous or nonhazardous waste) ambiguous. Coal ash, which was considered in Part One, has a variable heavy metal content depending on the source of the coal burned. Similarly the composition of wastewater sludges in the paper industry are partially dependent on the characteristics of incoming materials. Firms which process wastepaper have particularly variable sludges due to a lack of control over wastepaper inputs.

The analysis will focus on assumptions about waste streams which are based on the limited empirical data. In some cases, assumptions about large, highly heterogeneous waste quantities are made from one or two test observations. Clearly the data base for proper classification of wastes is inadequate for this industry. This study should not be considered to be making a determination of which industry

**Preceding page blank**

wastes may be hazardous. The development of an adequate data base is likely to take several years.

## 6.2 Waste Characteristics

Each of the four major solid waste streams of the industry are discussed below in a separate section. The waste streams considered are wastewater sludge, bark and wood wastes, coal and bark ash, and wastepaper reclamation wastes. Additional subsections are included for two waste streams from the kraft pulping process.

### 6.2.1 Wastewater Treatment Sludges

Wastewater treatment sludge is generated in the process of clarifying liquid plant effluents for discharge. Primary wastewater treatment is used to reduce the suspended solids content of the effluent. Recovered materials consist of fiber, fiber debris, bark, and those filler and coating materials which escape internal recovery systems. The most common method of primary treatment is sedimentation.[1] These methods usually employ a gravity clarifier or a lagoon with adequate retention time to settle out suspended solids. Filtration or flotation methods can also be used.

Secondary treatment involves the removal of biological oxygen demand (BOD) caused by dissolved organic constituents in the effluent. BOD reduction is accomplished using activated sludge or aerated lagoon methods. In the first process the primary treatment effluent flows into an aeration basin where it is contacted with the "activated sludge" and oxygen. The activated sludge is biologically active material which feeds on organic matter, removing it from the wastewater. The resulting biological mass from the aeration basin is separated from the final effluent and recycled as the "activated sludge." A portion of the sludge is disposed of in order to prevent sludge build-up.

Aerated lagoons are used to reduce BOD by contacting the effluent with a low concentration of biological organisms. This process is more land- and time-intensive, but produces a lesser volume of sludge.

As noted above, the major constituents of primary wastewater sludge are lost fiber and filler or coating materials. The relative proportions of organic and fiber constituents and inorganic filler material depends on the nature of mill operations. High ash concentrations (inorganic material) are typical in mills, which use de-inking processes, recycle wastepaper, or use large amounts of coating materials. The ash content can vary from a few percent to 50 percent or more. The water concentration of the sludge depends on the extent of dewatering and on the ash content. Sludges with high ash content have a higher solids concentration.

The trace element concentration in raw sludge is also widely variable, and dependent on either the specific process or the input fibers. Data on the chemical make-up of a sample of four primary and secondary sludges are provided in Table 6-1.

Of the metals tested for in these samples, three are included in the EPA Primary Safe Drinking Water Standards - namely chromium, cadmium and lead. These standards are incorporated into the RCRA Section 3001 (Options A and B)

## TABLE 6-1

## CHEMICAL COMPOSITIONS OF VARIOUS PAPER MILL SLUDGES

| PARAMETER | TYPE OF SLUDGE | | | |
|---|---|---|---|---|
| | DE-INKING SLUDGE FROM A RECYCLED PAPER OPERATION[a] | COMBINED PRIMARY AND SECONDARY SLUDGE FROM SEMI-CHEMICAL PULPING OPERATION[a] | PRETREATMENT SLUDGE FROM A PAPER COATING OPERATION[a] | COMBINED PRIMARY, SECONDARY SLUDGE[b] |
| Water (%) | 77.6 | 90-96 | 86 | 40 |
| Solids (%) | 22.4 | 4-10 | 14 | 60 |
| Ash (%) | - | 1-2.5[c] | - | 40 |
| Aluminum (ppm) | 21,300 | - | 100,000 | - |
| Calcium (ppm) | 4,390 | 4,000-15,000[d] | - | - |
| Chloride (ppm | 332 | - | - | - |
| Magnesium (ppm) | 1,170 | - | - | - |
| Manganese (ppm) | 16 | 250 | - | 1,146 |
| Total nitrogen (ppm) | - | 1,400 | - | 4 |
| Phosphorus (ppm) | 310 | - | - | 2 |

---

[a] Information submitted to the Wisconsin Division of Natural Resources as part of the solid waste disposal site approval process.

[b] Information received by ERCO from the P.H. Glatfelter Co.

[c] (AR) - sludge samples as received.

[d] (OD) - oven-dried basis on solids fraction.

TABLE 6-1 (CONT.)

| PARAMETER | TYPE OF SLUDGE | | | |
|---|---|---|---|---|
| | DE-INKING SLUDGE FROM A RECYCLED PAPER OPERATION[a] | COMBINED PRIMARY AND SECONDARY SLUDGE FROM SEMI-CHEMICAL PULPING OPERATION[a] | PRETREATMENT SLUDGE FROM A PAPER-COATING OPERATION[a] | COMBINED PRIMARY, SECONDARY SLUDGE[b] |
| Potassium (ppm) | 114 | 1,600 | - | - |
| Sodium (ppm) | 146 | 1,400 | - | - |
| Sulfate (ppm) | <0.03 | 120 | - | - |
| Cadmium (ppm)[c] | 32 | 1.5 | - | 4.6 |
| Chromium (ppm)[c] | 20 | - | - | 16 |
| Iron (ppm) | 538 | - | 200,000 | - |
| Lead (ppm)[c] | 32 | 120 | - | 47 |
| Nickel (ppm) | 2.3 | 25 | 3,000 | 52 |
| Zinc (ppm) | 151 | 260 | 4,000 | 397 |
| COD (ppm) | - | 60,000-120,000 | 400,000 | - |
| Phenol (ppm) | - | 5 | - | - |
| PCB (ppm) | - | <13 | - | - |
| Oil and grease (ppm) | - | 1 | - | - |

[a] Information submitted to the Wisconsin Division of Natural Resources as part of the solid waste disposal site approval process.

[b] Information received by ERCO from the P.H. Glatfelter Co.

[c] Regulated in EPA Primary Drinking Water Standards.

and are therefore basic to the classification of hazardous wastes. Each of the three metals is present in some concentration in the sludges tested. Much of the ensuing discussion will revolve around the presence of these metals in leachate analyses of wastewater treatment sludges.

Leachate analyses for a number of industry sludges were performed by the National Council of the Paper and Pulp Industry for Air and Stream Improvement (NCASI). Much of this information has not been published and cannot be presented here. However, information is available on some of the test results and is described below. Another principal source of information is a research study which has been sponsored by the Canadian government. The Canadian study will be reviewed after presentation of the National Council's results.

Leachate analyses were performed on two industry sludges using the Toxicant Extraction Procedure (RCRA Option A version). The sludges tested were from a de-inking mill and a boardmill. Both sludge types are as likely to be hazardous as any in the industry. The results of the tests are shown in Tables 6-2 and 6-3. Cadmium, chromium and lead concentrations were tested. Only lead of the three metals exceeds ten times the Primary Safe Drinking Water Standard. Lead is unacceptably high when strong acetic acid is used on boardmill sludge, and for both weak and strong acetic acid in the de-inking mill case.

The other metals tested for include iron, copper and zinc. These are included in the EPA Secondary Drinking Water Standards. Each of these is present in significant quantities in the raw sludge, although only zinc tended to leach out in any of the tests (iron was not tested). Copper appears to have little mobility for leaching out of the sludge.[2]

## TABLE 6-2

## SLUDGE COMPOSITION AND SLUDGE LEACHATE TESTS FOR BOARDMILL[a]

| | | | EXTRACTANT[b] | | |
|---|---|---|---|---|---|
| | RAW SLUDGE | DISTILLED WATER | WEAK ACETIC ACID | STRONG ACETIC ACID | RCRA LIMIT |
| pH of leachate | - | 6.4 | 4.6 | 4.5 | - |
| Chromium | 79 | <0.04 | <0.4 | <0.04 | 0.50 |
| Lead | 380 | <0.02 | 0.13 | 0.60 | 0.50 |
| Cadmium | NA | <0.01 | <0.01 | <0.01 | 0.10 |
| Iron | 2,400 | - | - | - | - |
| Nickel | 11 | <0.01 | <0.01 | <0.01 | - |
| Copper | 62 | <0.02 | <0.02 | <0.02 | - |
| Zinc | 350 | <0.02 | 2.4 | 2.4 | - |

[a] National Council for Air and Stream Improvement, Response of Selected Paper Industry Sludges to Alternate Solid Waste Toxic Extraction Procedures, Technical Bulletin No. 311, 1978.

[b] Results shown are for tests using a 1:4 ratio of dilution. Tests with slightly modified procedures were also conducted.

## TABLE 6-3

## SLUDGE COMPOSITION AND SLUDGE LEACHATE TESTS FOR DE-INKING MILL[a]

| | | EXTRACTANT[b] | | | |
|---|---|---|---|---|---|
| | RAW SLUDGE | DISTILLED WATER | WEAK ACETIC ACID | STRONG ACETIC ACID | RCRA LIMIT |
| pH of leachate | - | 7.7 | 4.6 | 4.3 | - |
| Chromium | 180 | 0.22 | <0.06 | <0.04 | 0.50 |
| Lead | 1,300 | 0.04 | 2.60 | 0.60 | 0.50 |
| Cadmium | NA | <0.01 | <0.01 | <0.01 | 0.10 |
| Iron | 1,500 | - | - | - | - |
| Nickel | 8 | <0.01 | <0.01 | <0.01 | - |
| Copper | 330 | <0.02 | <0.02 | <0.02 | - |
| Zinc | 300 | 0.04 | 2.4 | 2.4 | - |

[a] National Council for Air and Stream Improvement, Response of Selected Paper Industry Sludges to Alternate Solid Waste Extraction Procedures, Technical Bulletin No. 311, 1978.

[b] Results shown are for tests using a 1:4 ratio of dilution. Tests with slightly modified procedures were also conducted.

A summary of leachate tests performed by the National Council is provided in Table 6-4. Altogether, 13 representative paper industry sludges were tested. Eight samples did not show unacceptable trace-metal concentrations using the Option A TEP and these were not included here. Five sludges exceeded the RCRA limitation of ten times the Primary Safe Drinking Water Standards with Option A TEP. Retesting of sludges from these mills using the less stringent Option B TEP indicated no unacceptable amounts of trace metals.

TABLE 6-4

TESTS BY THE NATIONAL COUNCIL ON SLUDGE LEACHATE[a]

| MILL SLUDGE | WASTE | RCRA OPTION A<br>UNACCEPTABLE TRACE ELEMENT | RCRA OPTION A<br>QUANTITY[b] (ppm) (RCRA Limit) | RCRA OPTION B<br>UNACCEPTABLE TRACE ELEMENT | RCRA OPTION B<br>QUANTITY (RCRA Limit) |
|---|---|---|---|---|---|
| 1. Bleached kraft | Green liquor dregs, general refuse, primary sludge | Chromium | 0.59<br>(0.50) | None | - |
| 2. Kraft linerboard | Lime mud | Lead | <0.5<br>(0.50) | None | - |
| 3. Unbleached kraft specialty paper | Primary sludge | Lead | 0.6<br>(0.50) | None | - |
| 4. Kraft linerboard | Primary sludge | Lead | 2.1<br>(0.50) | None | - |
| 5. De-inking | Primary sludge | Lead | 1.0<br>(0.50) | None | |

[a] Speech by Dwayne Marshall at NCASI Conference, November 2, 1978.

[b] Approximate values.

In the EPA Priority Pollutants Program, pulp and paper mills are being required to reduce discharges of a variety of materials. The elemental discharges which have been of greatest concern to the industry and EPA are chromium, copper, nickel, lead, zinc and mercury. Reductions in the amounts of these chemicals requires that they be captured in the wastewater treatment sludges. In many cases, therefore, these elements will be present in wastewater sludges. The leachate tests discussed here indicate that only chromium and lead have sufficient mobility to leach out in unacceptable amounts.[3]

Another set of leachate analyses were performed by a Canadian firm, under the sponsorship of the Canadian Department of Fisheries and Environment.[4] For this study, large lysimeters were constructed and samples of pulp and paper mill wastes were added. The samples were then subjected to the equivalent of 100-inch annual rainfall for a period of 24 months. A summary of the study results are presented in Table 6-5 for four of the industry wastes. The waste streams studied include materials which are as likely to be hazardous as any in the industry. In particular, the combined wastes from a bleached kraft mill contained green liquor dregs (see Section 6.2.2). Also slaker grits or lime kiln rejects were added to the wastewater sludge of a groundwood mill.

The 24-month analysis represented a fairly stringent test of leachates from industry wastes. Maximum recorded values for trace metal concentrations are presented and, in a number of cases, they exceed RCRA standards. Once again, chromium and lead were offending substances. Silver also exceeded RCRA standards in three of four cases. Iron and manganese concentrations were extremely high in some

TABLE 6-5

2-YEAR LEACHATE ANALYSIS
MAXIMUM RECORDED VALUES (mg/l)[a]

| | BIOLOGICAL SLUDGE ON SPILLED FIBER | COMBINED WASTES FROM BLEACHED KRAFT MILL | COMBINED WASTEWATER SLUDGE, SLAKER GRITS AND LIME FROM GROUNDWOOD MILL | COMBINED WASTEWATER SLUDGE FROM GROUNDWOOD MILL | RCRA LIMITATION |
|---|---|---|---|---|---|
| Primary SDW | | | | | |
| Arsenic | ND | ND | ND | ND | 0.50 |
| Barium | 10 | 3 | 6 | 0.15 | 10 |
| Cadmium | ND | ND | ND | ND | 0.10 |
| Chromium | 0.5 | 2[c] | 1.5[c] | 1.5[c] | 0.50 |
| Lead | 60[c] | 5[c] | 30[c] | 12 | 0.50 |
| Mercury | NA | NA | NA | NA | 0.02 |
| Selenium | NA | NA | NA | NA | 0.10 |
| Silver | 0.7[c] | 1[c] | 2[c] | 0.04 | 0.50 |
| Secondary SDW | | | | | |
| Iron | 60 | 100 | 400 | 280 | - |
| Manganese | 100 | 15 | 100 | 70 | - |
| Zinc | 50 | 14 | ND | 0.15 | - |

---

[a] Econotech Services Limited, Consequences of Leaching from Pulp and Paper Mill Landfill Operations, September 1977.

[b] ND = not detectable.

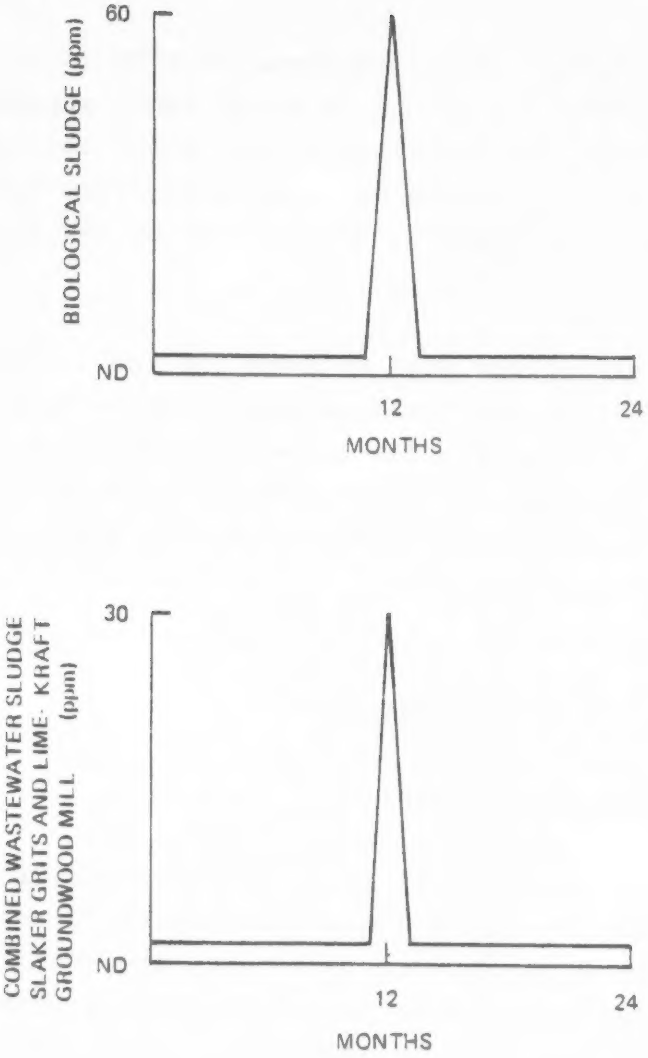
[c] Value exceeds RCRA limitation.

instances. However, the maximum recorded value figures can be misleading. It should be noted that for most metals, there was little leaching for a number of months. The leaching pattern of lead, for instance, is shown in Figure 6-1. The leaching of lead in each of the two cases was minimal until the halfway point in the study. Then a large quantity appeared in the leachate. No further lead concentrations were detected in either case.

It appears that the large rainfall simulation eventually washed out all of the metal concentrations. The test methods of the Canadian study may be more stringent than the RCRA TEP, but basically the tests are noncomparable. In order to make any statement from these various test results, the results of the National Council tests will be used. Because the National Council used RCRA-specified test procedures, their results are the most reliable available. It is thus assumed from these data that a number of industry sludges could be considered hazardous under the Option A TEP, but would be nonhazardous under the Option B TEP.

The Option A TEP includes the requirement that tested wastes show less than a specified level of aquatic toxicity. A Daphnia assay test is proposed with a waste being classified as toxic if its presence interferes with the reproduction or growth of the culture as defined in the test.

Results using the specified Daphnia assay test were not available. An indication of aquatic toxicity could be derived from the Canadian study, which used a rainbow trout (Salmo gairdneri) assay. Three types of paper industry sludge were tested: (1) biological (secondary) sludge, (2) sludge from a bleached kraft mill, and (3)



ND=Not Detectable

Figure 6—1. Two year leachate analysis-trends in lead content of leachate. (Econotech Services Limited,*Consequences of Leaching from Pulp and Paper Mill Landfill Operations*, Sept. 1977).

sludge from a groundwood mill. Leachates from all three sludges registered high initial toxicities (as measured in the LC50 test of the rainbow trout assay).[5] Over time the leachates from a given sample showed declining toxicity.

Interpreting these results in terms of RCRA is a problem. Aquatic toxicity in the Canadian study appears to involve a considerably more stringent test which utilizes undiluted leachate. The change of aquatic toxicity for these wastes under RCRA appears, in fact, to be low (based on tests made by NCASI).

The general assumption will be used for the economic impact analysis that wastewater treatment sludges will be hazardous under Option A TEP. The assumption will be the basis for the calculation of total eventual treatment costs. This assumption should not be interpreted as a conclusion based on the available test data.

### 6.2.2 Chemical Pulping Wastes

#### 6.2.2.1 Green Liquor Dregs

A waste stream produced in kraft pulping operations are dregs (solids) from the green liquor clarifier. Green liquor is produced at the chemical recovery stage of the kraft (chemical) pulping operation. The material consists of inert materials such as iron compounds, carbon, grit, refractory material and possibly sodium salts.[6] In most operations, green liquor dregs are added to the mill sewer system. Chemicals from the dregs would then end up in the wastewater treatment sludge. It will be presumed that green liquor dregs are added to the general mill waste stream and thus do not represent a separate waste stream. In some cases, the material will represent a separate stream, and quantity estimates are provided below for the green liquor dregs.

The characteristics for a wastewater treatment sludge made up largely of green liquor dregs were presented above. One of the sludge samples tested by the National Council (see Table 6-4) included green liquor dregs. The sludge mixture failed to pass the Option A TEP due to leaching of chromium, but passed the Option B TEP.

### 6.2.2.2 Lime Burning Wastes

One key step in modern alkaline (kraft) pulping is the reconstitution of the pulping liquor by recausticizing lime mud. Pulping costs would be prohibitive if only fresh lime were used. Chemical recovery in kraft pulping is the source of two related waste streams: slaker rejects and unburned lime rejects from lime-burning kilns.

Solid waste from slakers is in the form of lumps or pebbles whose composition will depend on the efficiency of the given slaking operation. The waste will consist of a mixture of inert particles and impurities carried through the chemical recovery system and some calcium carbonate. Lime kiln rejects are also mostly composed of inert contaminants which have passed through the recovery system and a small amount of unburned lime that will vary with individual kiln operation.

In sulfite pulping, chemical recovery solid wastes again involve the inevitable inert materials plus an oxide of the base cooking chemical (calcium, sodium, magnesium, or ammonia). The exact point at which this waste stream originates varies with mill design but is often at the ash washer or the cooking liquor filter.[7]

Lime burning wastes are possibly hazardous under the corrosivity tests under both RCRA options. No evidence was available concerning the performance of these wastes against the RCRA test protocol. Indirect evidence, based on pH readings, is inconclusive. The arbitrary assumption that wastes are hazardous will be used in the calculation of economic impacts.

### 6.2.3 Bark and Wood Wastes

Pulp mills generate large volumes of bark and wood wastes. Firms with bark boilers generally attempt to burn as much bark and wood as possible; however, many firms do not have bark boilers. Thus much of this solid waste is disposed of in landfills. Possible environmental hazards of disposal will be defined in terms of RCRA Section 3001 regulations in Options A and B. The only consideration for bark and wood waste disposal is possible toxicity. The more current Option B version of Section 3001 will be considered first, wherein the toxicity definition depends on the trace metal content of the leachate. The additional issue of aquatic toxicity will also be discussed. Aquatic toxicity is included in RCRA Option A.

Indications of the trace metal content of bark leachate are given in the 2-year Canadian study of pulp and paper mill wastes. Two types of bark were used in separate tests. These were Douglas fir bark and Western red cedar bark. The

## TABLE 6-6

## 2-YEAR LEACHATE ANALYSIS OF BARK, MAXIMUM RECORDED VALUES (mg/l)[a]

| | DOUGLAS FIR BARK | WESTERN RED CEDAR BARK | RCRA LIMITATION (10X SDW) |
|---|---|---|---|
| Primary SDW | | | |
| Arsenic | ND[b] | ND | 0.50 |
| Barium | 2.5 | 5 | 10 |
| Cadmium | ND | ND | 0.10 |
| Chromium | 0.6[c] | 1.8[c] | 0.50 |
| Lead | 1.0[c] | 3.0[c] | 0.50 |
| Mercury | NA | NA | 0.02 |
| Selenium | NA | NA | 0.10 |
| Silver | 0.05 | 0.2 | 0.50 |
| Secondary SDW | | | |
| Iron | 12 | 40 | - |
| Manganese | 3 | 8 | - |
| Zinc | 0.5 | ND | - |

[a] Econotech Services Limited, Consequences of Leaching from Pulp and Paper Mill Landfill Operations, September 1977.

[b] ND = not detected.

[c] Value exceeds RCRA limitation.

study authors assert that in general terms, characteristics for other tree species will be similar.[8]

Maximum recorded values in the generated leachate are shown in Table 6-6. For each bark type the trace metal concentrations are low. However, chromium and lead exceeded the RCRA standards at their peaks. Further examination of the test results for these metals is shown in Figure 6-2. The pattern of leaching for the chromium shows that after approximately 8 months, chromium value exceeded the RCRA

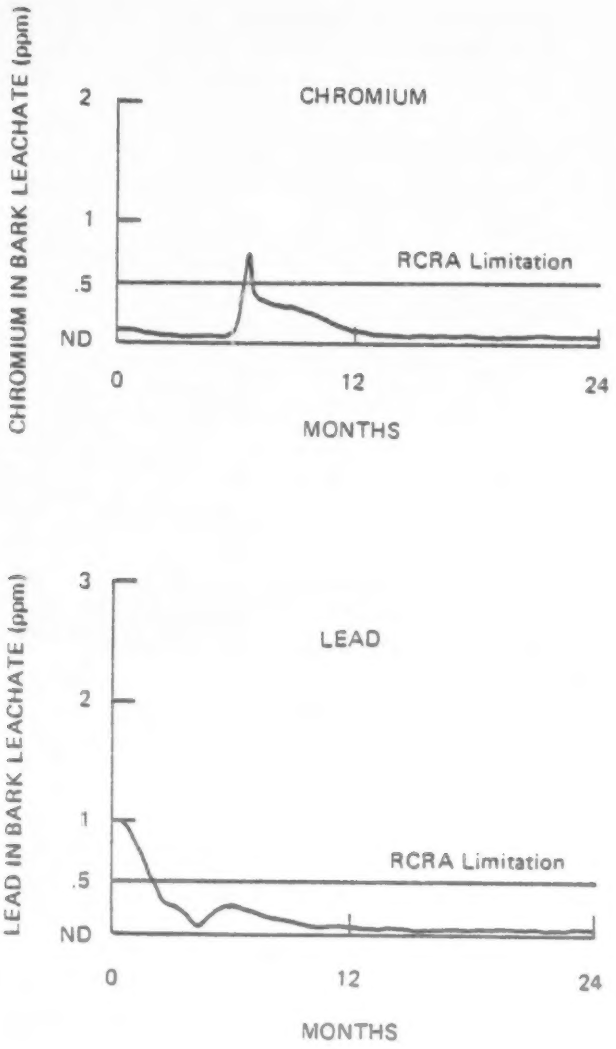


Figure 6–2. Patterns of leaching of chromium and lead from bark. (Econotech Services Limited, *Consequences of Leaching from Pulp and Paper Mill Landfill Operations*, Sept. 1977).

limitation. Lead values were high in the first leachate sample (taken after 4 weeks) and then immediately declined below the RCRA limitation. Whether or not lead values would exceed specified limits in the RCRA TEP test is uncertain. Chromium values do not appear to represent a problem although, as noted above, these tests are not strictly compared to the RCRA TEP.

Additional data in the Canadian study included field site tests from a number of wood waste disposal sites. Results of the tests are shown in Table 6-7. The proportion of wood and hog fuel at each site varies. In all of the field site tests shown, no metals exceeded RCRA limitations. Additional field site tests were made which are not shown here. Altogether 12 field sites were tested with similar results.

As a general conclusion, leachate from bark wastes can be expected to have very low metal concentrations. It appears possible for some lead to appear in bark leachate. It is doubtful, however, that this will be a major problem, judging from the testing of landfill sites. Bark wastes are therefore expected to pass the test for toxicity specified in Section 3001 of Option B.

RCRA Option A included requirements concerning the aquatic toxicity of a waste. A Daphnia assay test is proposed with a waste being classified as toxic if its presence interferes with reproduction or growth as defined in the test. No test results of paper industry wastes using this test were available. However, the Canadian study and other sources give indications of the aquatic toxicity of industry wastes.

TABLE 6-7

FIELD SITE TESTS OF BARK AND WOOD WASTE LANDFILLS (mg/1)[a]

| | A HOG FUEL | C HOG FUEL | D HOG FUEL | F HOG FUEL | G HOG FUEL | RCRA LIMITATION (10X SDW) |
|---|---|---|---|---|---|---|
| Primary SDW | | | | | | |
| Arsenic | ND[b] | ND | ND | ND | ND | 0.5 |
| Barium | 0.3 | 0.06 | 2.5 | 0.3 | 0.1 | 10.0 |
| Cadmium | ND | ND | ND | ND | ND | 0.1 |
| Chromium | 0.003 | Trace | 0.01 | 0.003 | 0.003 | 0.5 |
| Lead | 0.09 | 0.02 | 0.25 | 0.1 | 0.01 | 0.5 |
| Mercury | NA[c] | NA | NA | NA | NA | 0.02 |
| Selenium | NA | NA | NA | NA | NA | 0.1 |
| Silver | NA | 0.002 | 0.01 | ND | ND | 0.5 |

[a] Econotech Services Limited, Consequences of Leaching from Pulp and Paper Mill Landfill Operations, September 1977.

[b] ND = Not detected.

[c] NA = Not available or not tested for.

Bark and wood waste leachate contain a number of resin acids. The resin acids are generally regarded as toxic to aquatic organisms. Toxicity testing for the two barks used in the Canadian study consisted of a rainbow trout (Salmo gairdneri) assay. Results of the test are shown in Figure 6-3. Leachates from the two barks were highly toxic initially but rapidly declined to zero as measured by the LC50 test. Other sources have noted the apparent toxicity of bark and wood wastes.[9] However, as noted previously, the Canadian study appears to represent a more stringent test of aquatic toxicity. Available information based on a small amount of testing by NCASI (unpublished results) indicates that these wastes would pass the requirements.

In light of this uncertainty, an assumption about toxicity will be made. It will be assumed that these wastes are hazardous under Option A and not hazardous under Option B.

### 6.2.4 Coal and Bark Ash

The pulp and paper industry generates a significant portion of its own electricity. In many cases the fuels used include coal and bark. Bark and hog fuel (wood chips unsuitable for pulping) can be burned if modifications are made in the standard boiler or if a special bark-burning furnace is purchased.

The characteristics of coal ash leachate were discussed in the previous part and no additional discussion is included here, except where combined coal and bark ash characteristics are presented. It will be assumed that coal ash adds to the quantity of hazardous waste for the industry.

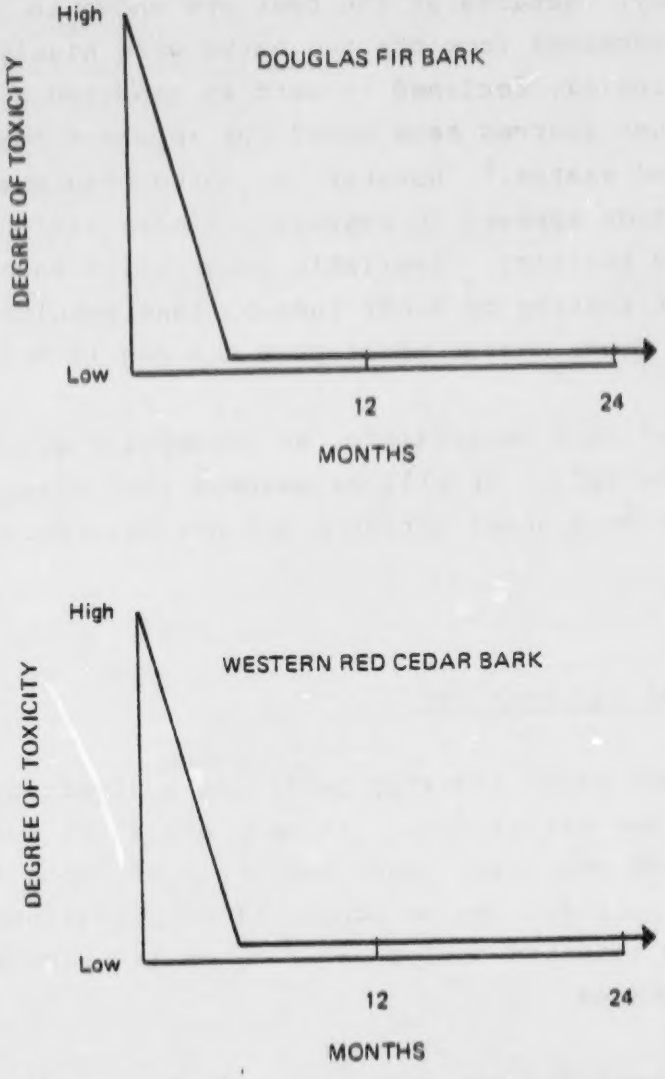


**Figure 6–3.** Toxicity of bark samples, LC50 Test-Rainbow trout assay. (Econotech Services Limited, *Consequences of Leaching from Pulp and Paper Mill Operations*, Sept. 1977).

Bark typically contains approximately 3 percent ash. The principal chemical constituents to bark ash are calcium oxide and silicon dioxide. As noted in the previous section, trace metal concentrations in bark leachate are very low. Trace element concentrations in bark ash will be similarly very low although no data could be uncovered which addressed this point directly. It will be concluded, given the low concentrations in bark, that bark ash leachate will have acceptably low metal concentrations. However, for Option A, the uncertainties of the broader test requirements will be covered by an assumption of toxicity.

### 6.2.5 Wastepaper Reclamation Wastes

One major source of solid waste in industry segments using secondary fiber is reclamation waste. Contaminants present in wastepaper must be removed before a new product of acceptable and uniform quality can be made. These contaminants include wire, strapping, tramp metal, glass, plastics, dirt, and other foreign materials as well as coatings, inks, fillers, and additives which are part of paper manufacturing processes. The degree of contamination and the amount of extraneous additives will vary with each batch of wastepaper and with the requirements of any given secondary fiber operation.

Much of the foreign material can be removed using simple sorting techniques and presents no hazardous waste problem. However, depending on the wastepaper source it is possible for nearly anything to enter the waste stream.[10] It is possible that potentially hazardous papermaking additives may contaminate the otherwise innocuous solids removed in repulping. Because of the heterogeneity of this waste stream, and the wide variability in waste loads among individual mills and among individual batches of wastepaper, it is difficult to state conclusively what wastes will be hazardous. Under the more stringent criteria of the RCRA Option A regulations, it is possible that some wastepaper reclamation wastes, because of the possibility that they might come in contact with toxic additives, pigments, or inks, would be declared hazardous. Under Option B, such a classification is not as likely. To reflect these possibilities, Option A is assumed to define wastepaper reclamation wastes as hazardous; Option B is assumed to classify these wastes as nonhazardous.

### 6.2.6 Specialty Product Wastes

Little information is available on the characteristics of solid waste streams generated at specialty paper mills. The addition of noncellulosic materials to the manufacturing process will presumably add unusual ingredients to the eventual wastewater treatment sludge.

Examples of specialty products include solvent-coated papers, zinc oxide-coated papers, high wet-strength papers and other industrial specialty products.[11] The list of additives currently being used includes aluminum and silicon oxides, zinc oxides, calcium carbonate, titanium dioxide, ureaformaldehydes, polystyrene, acrylic, polyvinyl acetates and phenol-based materials.

The concentrations of these materials in mill sludges can only be inferred on a mill-by-mill basis. These mills currently have effluent limitations defined on a mill-by-mill basis by EPA. A partial indication of leaching characteristics can be derived from the analyses given above of sludges from de-inking or boardmill sludges. Zinc and lead appear to be the metals which tend to leach from wastepaper feedstocks, and are therefore probably evident in some specialty mill sludges.

### 6.2.7 Miscellaneous Waste Streams

Waste streams described below constitute distinct sources of paper industry wastes but are of minor importance compared to the massive volumes of other solid wastes like bark or coal ash. Therefore, no estimates of waste volumes are made for these sources. Brief descriptions of their origin and composition are included below for the sake of completeness.

#### 6.2.7.1 Evaporator Residues

Part of the chemical operations typical of current chemical pulping include the evaporation of waste pulping liquor to increase its value as a source of process heat and to increase the concentrations of active chemicals. However, any evaporation process inevitably encourages the precipitation of small amounts of entrained solids. As a result, precipitated solids accumulate in evaporators and must occasionally be cleaned out. This constitutes a distinct waste stream though the quantity of waste involved is almost negligible. Evaporators are cleaned with heated solutions of various solvents or simply boiling water to remove scale. The cleaning occurs no more often than once a week at most, and typically once every several weeks.[12] Evaporation scale is varied in composition, but usually includes inert materials and undissolved metals, particularly calcium. Depending on the toxicity of cleaning agents, this waste stream may or may not be considered hazardous. Acidic cleaning agents could be added to the general mill effluent for neutralization.

### 6.2.7.2 Tall Oil Residues

One byproduct of the chemical reactions in sulfate pulping is the release of fatty acids and resin acids present in wood into the cooking liquor as sodium soaps. These acids and associated black liquor impurities constitute what is known as tall oil soaps. These have a great many uses in adhesives, emulsions and wetting agents, disinfectants, lubricants, paints and varnishes, and soap. In the process of achieving the desired solids concentration for separating the soaps from the black liquor, the liquor passes through a series of evaporators. The solids which precipitate out constitute another solid waste stream very similar to that discussed above.[13]

After the black liquor is free of tall oil soaps, it is returned to the chemical recovery process. Any additional wastes dissolved in the black liquor are generated as part of chemical recovery rather than as part of tall oil recovery.

### 6.2.7.3 Parchmentizing

Some specialty mills perform an additional paper treatment called parchmentizing. In this process, paper is treated with successive washes of sulfuric acid in order to reduce the moisture content in the paper. The resulting product is a dry, brittle "parchment like" paper. The acid wash treatment involved does not appear to generate a separate, hazardous waste source. This waste rinse is normally neutralized by interaction with the plant wastewater stream.

## 6.3 Solid and Hazardous Waste Quantities

Estimates of solid waste quantities for the wastes examined will be presented in this section. The portion of industry wastes which are classified as hazardous will depend on whether RCRA Option A or B is being considered.

A summary of the waste designation to be used in estimating the volumes of hazardous waste are shown in Table 6-8. Simple industry breakdowns have been used to represent the major types of the industry waste streams. As can be seen from the table, most wastes will be assumed hazardous under Option A while few wastes are likely to be hazardous using Option B.

The waste designations can only be considered to be assumptions. Data is inadequate to define the range of possible compositions for wastes within the broad categories used. Areas of particular concern are the composition of sludge from mills using secondary fibers, coating materials and the sludge from kraft mills. However, the data base covering all of these wastes is very limited.

### 6.3.1 Model Plant Waste Quantities

Model plants were described in the previous chapter. Here, waste streams from these plants will be described.

TABLE 6-8

HAZARDOUS WASTE DESIGNATIONS IN THE PULP AND PAPER INDUSTRY[a]

|  | OPTION A |  | OPTION B |  |
|---|---|---|---|---|
| WASTE STREAM | DESIGNATION | CHARACTERISTIC | DESIGNATION | CHARACTERISTIC |
| Wastewater treatment sludge:<br>Kraft mills | Hazardous | Toxicity | Nonhazardous | - |
| Secondary fiber mills:<br>De-inking mill<br>Recycled boardmill<br>Virgin fiber mills | Hazardous | Toxicity | Nonhazardous | - |
| Coal ash | Hazardous | Toxicity | Hazardous | Toxicity |
| Bark ash | Hazardous | Toxicity | Nonhazardous | - |
| Bark and wood wastes | Hazardous | Toxicity | Nonhazardous | - |
| Additional chemical pulping wastes:<br>Slaker rejects<br>Lime kiln mud | Hazardous | Corrosiveness | Hazardous | Corrosiveness |

[a] The hazardous waste designations are tentative conclusions based on available data.

The average plant is a kraft pulping mill and the worst-case plant is a recycled boardmill plant.

There are a total of four potentially hazardous waste streams from the model and worst-case plants: coal ash, wastewater treatment sludge, chemical pulping solid wastes, and secondary fiber or repulping solid wastes. The wastes and their status under Options A and B are summarized in Table 6-9.

Since the "model" plant usually burns non-coal fossil fuels, it has no coal ash for disposal.[14] However, since coal ash is considered hazardous under both Options, the "worst case" plant is assumed to be using coal to generate all process heat (the "average" kraft mill requires 6.3 MMBtu per metric ton of product while the recycled boxboard mill requires 11 MMBtu per metric ton).[15] In the model plant, bark is burned to generate process steam so that there are no bark wastes, except for bark ash, which is considered non-hazardous under both Options.

Wastewater treatment sludge includes primary and secondary sludge on a dry weight basis. These quantities are based on an 83 percent sample of the industry's mills in a 1975 survey made by NCASI. The survey results are described more completely in the next section.

Chemical pulping solid wastes include green liquor dregs and lime slaker rejects based on 1971 data collected by Gorham International. Repulping wastes include all material rejected as waste or unsuitable for repulping from incoming raw material.

## TABLE 6-9
## MODEL PLANT: WASTE QUANTITIES[a]

| WASTE STREAM | ESTIMATED HAZARDOUS WASTE QUANTITIES (MT/yr) | | | |
|---|---|---|---|---|
| | OPTION A | | OPTION B | |
| | MODEL PLANT | "WORST CASE" | MODEL PLANT | "WORST CASE" |
| Coal ash | NA[b] | 14,900 | NA | 14,900 |
| Wastewater treatment plant sludge | 10,900 | 2,100 | NA | NA |
| Chemical pulping solid wastes | 5,500 | NA | 5,500 | NA |
| Repulping solid wastes | NA | 11,000 | NA | NA |
| Total | 16,400 | 28,000 | 5,500 | 14,900 |

[a] See notes to Table 6-9 on following page.

[b] NA = not applicable.

## NOTES TO TABLE 6-9

1. Model plant: 910 MTPD virgin unbleached kraft linerboard mill, 345 operating days per year.

2. "Worst-case" plant: 360 MTPD secondary fiber folding boxboard mill, 330 operating days per year.

3. The coal ash estimate assumes a process heat requirement of 11 MMBtu/MT of product (Arthur D. Little, *Cost of Pulp and Paper Mill Compliance with Environmental Regulations*, EPA, May 1977, p. H-5), 40 percent efficiency in generation of process steam, 12,000 Btu/lb of coal, and a 12 percent content:

$$\frac{11\ \text{MMBtu/MT}}{(12{,}000\ \text{Btu/lb} \times 2.2\ \text{lb/kg} \times 0.40\ \text{efficiency})} \times 0.12\ \text{ash}$$

= 125 kg ash/MT product.

The plant is assumed to be operating 330 days per year making 360 MTPD, resulting in 14,900 MT/yr of ash.

4. Primary wastewater treatment sludge is based on average rates per metric ton of product, provided by Dwayne Marshall of the National Council of the Paper Industry for Air and Stream Improvement in conversation November 21, 1978. These are 31 kg/MT of product for "kraft paperboard, packaging papers, news, and tissues," applied to the kraft linerboard model plant, and 16 kg/MT of product for "recycled paperboard," applied to the recycled boxboard model plant.

Only total secondary treatment sludge for industry product catogeries was provided by the NCASI rather than a generation rate as was provided for primary sludge. Therefore, a secondary sludge generation rate was estimated here by simply (1) dividing the relevant category's total primary sludge by the given primary sludge rate to estimate that category's production (2) dividing that category's given total secondary sludge by its production to estimate an average rate. This resulted in 3.9 kg/MT and 1.7 kg/MT for the average and worst-case plants respectively.

5. Chemical pulping solid wastes are based on a rate of 17.5 kg/MT of product, the midpoint of a 15-20 kg/MT rate cited in Gorham International, *Solid Waste Management Practices in the Pulp and Paper Industry*, EPA Office of Solid Waste Management Programs, Contract 68-03-0207, February 1974, p. 72.

6. Repulping solid wastes are taken from pulping paperboard making losses assumed at 93 kg/MT product (Arthur D. Little, *Cost of Pulp and Paper Mill Compliance with Environmental Regulations*, EPA, May 1977, p. E-7).

### 6.3.2 Waste Stream Quantities

#### 6.3.2.1 Wastewater Treatment Sludge Quantities

The quantity of wastewater treatment sludge varies with the industry subcategory and with mills within each subcategory. Ranges of generation of primary sludge for the industry groups are shown in Table 6-10. In some cases, such as for kraft paperboard mills, a factor of 4 could separate the sludge generation rates at different mills. The ranges are taken from a NCASI survey of sludge generation and disposal in 1972. Average figures are taken from a NCASI 1975 survey. The rate of sludge generation is equivalent to from 1 to 4 percent of production.[16]

Aggregate quantities of sludge are shown in Table 6-11. The aggregated figures were based on the average sludge quantities estimated in the National Council Survey. Quantities of both primary and secondary sludge are included. The distribution of mills among subcategories was approximate due to the lack of clear distinctions between some processes. For the calculation of 1977 quantities, the estimates were scaled upwards in accordance with the increase in paper production.

#### 6.3.2.2 Chemical Pulping Waste Quantities

The estimated quantities of chemical pulping wastes are based on data presented in Table 6-12 below. Sulfate pulping wastes amounted to an estimated average of 711,800 MT in 1975. This figure includes green liquor dregs. This value was scaled up to 1977 production in accordance with the 1975 to 1977 increase in pulp production. Sulfite

TABLE 6-10

AGGREGATE SLUDGE QUANTITIES (000 tons)[a]

| SUBCATEGORY | PRIMARY SLUDGE WET WEIGHT | PRIMARY SLUDGE DRY WEIGHT | SECONDARY SLUDGE DRY WEIGHT | COMBINED SLUDGE DRY WEIGHT | COMBINED SLUDGE DRY WEIGHT (000 MT) |
|---|---|---|---|---|---|
| Kraft paperboard, packaging papers, tissue | 3,240 | 713 | 89 | 802 | 727 |
| Kraft coated and uncoated papers | 1,688 | 422 | 35 | 457 | 414 |
| Sulfite tissue and paper | 345 | 69 | 46 | 115 | 104 |
| Groundwood newsprint, coated and uncoated papers (from purchased kraft pulp in addition to groundwood mill) | 1,735 | 347 | 22 | 369 | 335 |
| NSSC/semi-chemical | 245 | 49 | 19 | 68 | 62 |
| De-inked tissue, coated and uncoated papers | 624 | 187 | 23 | 210 | 190 |

---

[a] Dwayne Marshall, Nature and Behavior of Manufacturing-Derived Solid Wastes of Pulp and Paper Origin, Preliminary Draft, November 1978.

TABLE 6-10 (CONT.)

| SUBCATEGORY | PRIMARY SLUDGE | | SECONDARY SLUDGE DRY WEIGHT | COMBINED SLUDGE DRY WEIGHT | COMBINED SLUDGE DRY WEIGHT (000 MT) |
|---|---|---|---|---|---|
| | WET WEIGHT | DRY WEIGHT | | | |
| Recycled paperboard | 250 | 65 | 7 | 72 | 65 |
| Nonintegrated papers (recyled) | 580 | 174 | 3 | 177 | 161 |
| Nonintegrated tissue | 468 | 108 | 60 | 168 | 152 |
| Total | 9,165 | 2,134 | 304 | 2,438 | 2,211 |

## TABLE 6-11

## PRIMARY SLUDGE GENERATION PER UNIT OF PRODUCTION[a]

| SUBCATEGORY | GENERATION RATE<br>GENERATION RANGE (lb/ton) | AVERAGE (lb/ton) | AVERAGE (kg/MT) |
|---|---|---|---|
| 1. Kraft paperboard Packaging paper integrated with Kraft operations | 20-80 | 62 | 31 |
| 2. Kraft coated and uncoated papers | 60-160 | 136 | 68 |
| 3. Sulfite tissue and paper | 60-140 | 92 | 46 |
| 4. Groundwood newsprint, coated and uncoated papers | 60-120 | 112 | 56 |
| 5. NSSC | 20-60 | 24 | 12 |
| 6. De-inked tissue, coated and uncoated papers | 80-300 | 312 | 156 |
| 7. Recycled paperboard | 0-60 | 32 | 16 |
| 8. Nonintegrated papers | 20-80 | 60 | 30 |
| 9. Nonintegrated tissue |  | 108 | 54 |
| 10. Nonintegrated tissue from wastepaper |  | 418 | 209 |

[a] Dwayne Marshall, Nature and Behavior of Manufacturing Derived Solid Wastes of Pulp and Paper Origin, December 1978.

## TABLE 6-12

## CHEMICAL PULPING WASTES[a]

| | VOLUME (MT/yr)[b] |
|---|---|
| Sulfate pumping | |
| Green liquor dregs | 263,900 |
| Slaker rejects | 447,900 |
| Sulfite pumping | 17,100 |

[a] Battelle Columbus Laboratories, "Draft Report on Cross Media Impact of the Disposal of Hazardous Wastes from the Wood Products and Related Industries," October 1977.

[b] Estimated quantities in 1971.

pulping wastes are estimated at 17,100 MT for 1971 and were also scaled upward. Total wastes for 1977 were approximately 847,000 MT, of which 532,000 MT consisted of slaker rejects.

### 6.3.2.3 Coal Ash Quantities

The ash content of coal varies from 5 to 30 percent depending on the source and type of coal. For the purposes of estimation a 12 percent ash content will be assumed. The amount of coal burned at a given mill is dependent, of course, on a large number of factors including the amount of other fuels being burned. Table 6-13 gives a sample of the amount of coal burned at three separate pulping mills. The amount of coal burned, the amount of product produced and the annual ash quantities to be disposed of are all indicated. The range for the plants shown for annual coal consumption is roughly 100,000 to 300,000 metric tons per year.

TABLE 6-13

SAMPLE COAL CONSUMPTION AT THE THREE MILLS
(000 MT)

| MILL TYPE | ANNUAL COAL CONSUMPTION | ANNUAL PULP OR PAPER PRODUCTION | ESTIMATED OR ACTUAL ASH VOLUMES | VOLUME OF ASH (MT) PER MT OF PRODUCTION |
|---|---|---|---|---|
| Bleached[a] kraft | 107 | 277 | 13 | 0.05 |
| NSSC pulp | 158 | 216 | 19 | 0.08 |
| Bleached kraft | 319 | 272 | 38 | 0.13 |

[a] Gorham International Inc., Study of Solid Waste Management Practices in the Pulp and Paper Industry, February 1974.

Annual coal consumption for the industry in 1977 was 8.1 million metric tons.[17] Aggregate ash quantities are estimated at 0.98 million metric tons.

### 6.3.2.4 Bark and Wood Waste Quantities

Bark quantities can be estimated based on the amount of incoming roundwood. Small quantities of wood waste will also be generated. However, wood waste at a pulp mill is predominantly bark so the bark estimation procedure, although rough, is useful. The quantity of bark per unit of incoming roundwood can fluctuate widely. Estimates for averages of bark generated vary from 40 kg (dry weight) to 56 kg (dry weight) per incoming cubic meter (320 to 450 lb/cord).[18] The figure of 50 kg/m$^3$ will be used here. Total roundwood consumption by the industry in 1977 amounted to 159.3 million cubic meters (44 million cords).[19] Bark wastes are thus estimated at 8.0 million metric tons by dry weight (assuming a 50 percent moisture content, 16.0 million MT wet). Of this 5.3 million metric tons or 66 percent was burned for fuel, leaving 2.7 million metric tons to be landfilled.[20]

### 6.3.2.5 Secondary Fiber Reclamation Wastes

The aggregate quantity of secondary fiber reclamation waste was developed based on estimates of quantity per unit of production for the de-inking, paperboard, and non-integrated fine papers segments. The aggregate total was derived from 1977 production values. The aggregate volume for 1977 is estimated at 1.69 million metric tons.[21]

## 6.4 Number of Generators

As discussed in Chapter Five, there are over 775 pulp and paper mills in the United States. In some cases, however, several contiguous mills are jointly owned. These mill complexes will be counted as one generator. On this basis, the total numbers of possible generators is 561, as derived from the ADL study, Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations (1977). The number of generators under each RCRA option is discussed further in Section 6.7.2.

## 6.5 Current Disposal Practices

Most solid waste generated in the paper industry is disposed of by land application. A survey of disposal practices for wastewater sludges in 1975 is shown in Table 6-14. As can be seen, land application is most common but a variety of disposal methods are possible. Sludge with a high fiber content can be incinerated or recycled back into the process as an input. A few mills are able to sell sludge because of its fertilizer and landplacing because the latter does not imply covering. A number of mills, particularly those in rural areas, have traditionally piled wastes at sites near the plant.

Coal ash is generally disposed of at the same site as wastewater sludge and other wastes. Some mills have separate landfill sites for boiler residues but this does not appear to be common practice.

Similarly hog fuel wastes are commonly landfilled. The field sites examined in the Canadian study (see Section 6.2)

## TABLE 6-14

## DISPOSAL OF PAPERMILL SLUDGES IN 1975

| METHOD | NUMBER OF MILLS | DRY WEIGHT (ton/day) | PERCENT OF TOTAL |
|---|---|---|---|
| Incineration | 19 | 321 | 10 |
| Landfilled | 40 | 1,040 | 33 |
| Landplaced | 53 | 1,233 | 39 |
| Incinerator and landfilled | 4 | 82 | 3 |
| Incinerator and landplaced | 4 | 68 | 2 |
| Recycled | 5 | 31 | 1 |
| Sold | 3 | 5 | - |
| Lagoon | 13 | 221 | 7 |
| Municipal/Contractor | 3 | 6 | - |
| Municipal and landplaced | 7 | 25 | 1 |
| Municipal and landfilled | 3 | 11 | - |
| Other | 9 | 96 | 4 |
| Totals | 163 | 3,159 | 100 |

[a] National Council for Air and Stream Improvement, Sludge Dewatering and Disposal Practices in the U.S. Paper Industry, August 1978.

typically involved simple landfilling of wastes with or without cover provided. In a number of cases, marsh land near the mill was used for disposal. In some cases, hog fuel wastes are used as fill for marshland recovery.[27]

Most landfill sites are adjacent to the mill since any transportation requirements increase disposal costs. Most firms which do transport wastes from the mill do not haul it more than a mile or two from the plant.[23] Additional waste streams from pulping processes, such as slakers rejects or green liquor dregs, may be added to the general plant effluent or disposed of separately. No figures were available on the number of firms using each disposal method. However, it appeared, based on discussions with industry personnel, that green liquor dregs were commonly disposed of in the general mill effluents.

## 6.6 RCRA-Required Disposal Methods

Paper industry wastes will require disposal in secure landfills under RCRA. Additional treatments, such as neutralization, will not be necessary.

Alternative disposal may be acceptable for the relatively small-volume chemical pulping wastes. Some firms currently dump these wastes into the general mill effluents. The resulting wastewater treatment sludge may nevertheless not be considered hazardous. As noted above in Section 6.2.1, existing tests have shown that the resulting sludge is likely to be classified as hazardous only under the TEP of Option A. However, landfilling of these wastes has been assumed to be an adequate disposal method.

## 6.7 Compliance Costs

### 6.7.1 Technical Costs

Original landfill estimates were not developed for paper industry landfills. Instead, the landfill costs developed by another EPA contractor (Battelle Columbus Laboratories) will be used.[24] For each RCRA option, landfills sized according to the amount of hazardous waste were being disposed of by the model firms. Model plant disposal costs were linearly interpolated between costs estimated for specific yearly waste volumes in the Battelle study. For example, the estimated wastes from the unbleached kraft linerboard mill (16,400 MT of wastes under Option A) fell between the yearly disposal volumes of 16,800 MT and 14,400 MT for which costs of $28/MT and $29/MT were presented. Linear interpolation to estimate the disposal cost of the model plant gave $28.2/MT. Yearly wastes for the same plant under Option B are 5,500 MT. The interpolated value for the model plant is $44.3/MT.

### 6.7.2 On/Offsite Allocation of Paper Mill Disposal Operations

Because there is no direct count of the number of mills using a given waste disposal method, rough estimates were made of the on/offsite disposal split for RCRA Options A and B. Under Option A, offsite disposal was assumed for all mills using municipal wastewater treatment plants and for all small mills not integrated to pulp. In other words, mills with their own wastewater treatment plants are assumed to have an onsite sludge disposal area which could potentially be modified for hazardous waste disposal. (In effect, this assumes that mills presently disposing of a sizeable waste stream will find it easiest to construct hazardous waste landfills). Small nonintegrated mills are expected to use offsite disposal because it is likely they face land constraints by virtue of their location closer to urban areas.

A breakdown of U.S. pulp and paper mills by process size and wastewater treatment status is provided in work by another EPA contractor.[25] That study puts the number of mills using municipal treatment at 154. There are an additional 82 small nonintegrated plants not on municipal systems for an estimated total of 236 offsite waste disposers.

The estimate for Option B is slightly more involved. First, an estimate had to be made of the number of generators based on an estimate of mills generating chemical pulping wastes and coal ash. Of the 168 mills using chemical pulping processes, it was assumed that 10 percent, or 17, also burn coal, since 10 percent of the industry's self-generated energy was from coal. The estimated total number of coal-burning mills is 10 percent of 561 or 56, for an additional 39 mills. The total number that either burn coal or use chemical pulping or both is 207. The offsite disposers are assumed to be the small chemical pulp mills (those averaging 250 MT per day of production) of which there are 30, and small nonintegrated mills burning coal, estimated at 10 percent of 135, for a total of 44 mills disposing of their wastes offsite.[26]

### 6.7.3 Administrative Costs

The administrative costs for the paper industry compliance are shown in Tables 6-15, 6-16, and 6-17. Costs are displayed for both onsite and offsite disposal. The costs are derived from those developed by another EPA contractor, Arthur D. Little.[27] A number of judgments were made as to the applicability of specific tasks.

The major cost elements are waste analysis, monitoring, daily inspections, development of a site description (for permitting), and financial responsibility costs. Under Option B some of these costs were reduced because smaller landfill sites would be used.

## TABLE 6-15

## RCRA ADMINISTRATIVE COSTS FOR ON-SITE DISPOSAL (OPTION A)[a]

| ADMINISTRATIVE TASK | COST ($) | |
|---|---|---|
| | FIRST YEAR | RECURRING YEAR |
| Section 3001 | | |
| Waste analysis ($2,300/test, 5 tests/yr for 3-5 waste streams) | 34,500 | 34,500 |
| Documentation of waste analysis | 240 | |
| Supervision of testing, documentation | 50 | 50 |
| Section 3002 | | |
| Application for I.D. Code | 32 | - |
| Section 3004 | | |
| Surface water monitoring[b] | 21,000 | 21,000 |
| Groundwater monitoring | 6,200 | 6,200 |
| Notification of disposal operations | 32 | - |
| Reporting of disposal data | 1,136 | 1,136 |
| Reporting of monitoring data | 260 | 260 |
| Develop contingency plan | 493 | - |
| System design for proper facility operation | 2,142 | - |
| Daily inspections | 20,075 | 20,075 |
| Updating of procedures | 811 | 811 |
| Section 3005 | | |
| Develop description of site | 42,600 | - |
| Design financial requirement plan | 1,340 | - |
| Assess and redesign facility | 1,730 | - |
| Understanding of permit (legal aid) | 1,790 | - |
| Training program | 13,750 | 4,500 |
| Contingency plan costs | 4,000 | - |
| Continuing supervision | 1,000 | 1,000 |
| Financial responsibility costs | 63,000 | 63,000 |
| Total | 216,181 | 152,532 |
| Annualized costs | 162,888 | |

[a] ERCO estimate.

[b] Assumes $350/sample with testing at 6 sites, 10 times per year.

## TABLE 6-16

## RCRA ADMINISTRATIVE COSTS FOR ON-SITE DISPOSAL (OPTION B)[a]

| ADMINISTRATIVE TASK | COST ($) | |
|---|---|---|
| | FIRST YEAR | RECURRING YEAR |
| Section 3001 | | |
| Waste analysis ($2,300/test, 5 tests/yr for 3-5 waste streams) | 34,500 | 34,500 |
| Documentation of waste analysis | 240 | |
| Supervision of testing, documentation | 50 | 50 |
| Section 3002 | | |
| Application for I.D. Code | 32 | - |
| Section 3004 | | |
| Surface water monitoring[b] | 21,000 | 21,000 |
| Groundwater monitoring | 6,200 | 6,200 |
| Notification of disposal operations | 32 | - |
| Reporting of disposal data | 1,136 | 1,136 |
| Reporting of monitoring data | 260 | 260 |
| Develop contingency plan | 493 | - |
| System design for proper facility operation | 2,142 | - |
| Daily inspections | 10,040 | 10,040 |
| Updating of procedures | 811 | 811 |
| Section 3005 | | |
| Develop description of site | 11,000 | - |
| Design financial requirement plan | 1,340 | - |
| Assess and redesign facility | 1,730 | - |
| Understanding of permit (legal aid) | 1,790 | - |
| Training program | 2,000 | 1,000 |
| Contingency plan costs | 4,000 | - |
| Continuing supervision | 1,000 | 1,000 |
| Financial responsibility costs | 21,000 | 21,000 |
| Total | 120,796 | 96,997 |
| Annualized costs | 100,869 | |

[a] ERCO estimate.

[b] Assumes $350/sample with testing at 6 sites, 10 times per year.

TABLE 6-17

RCRA ADMINISTRATIVE COSTS FOR OFF-SITE DISPOSAL
(OPTIONS A and B)[a]

| TASK | OPTION A COSTS ($/yr) | | OPTION B COSTS ($/yr) | |
|---|---|---|---|---|
| | FIRST YEAR | RECURRING | FIRST YEAR | RECURRING |
| Section 3001 waste analysis | 34,500 | 34,500 | 34,500 | 34,500 |
| Documentation of wastes | 240 | - | 240 | - |
| Supervision of documentation | 50 | 50 | 50 | 50 |
| Section 3002 application for I.D. code | 32 | - | 32 | - |
| Reporting of generation | 586 | 586 | 242 | 242 |
| Storage of manifests | 20 | 20 | 20 | 20 |
| Manifests ($3/manifest, 1/wk) | 156 | 156 | 156 | 156 |
| System design for handling, disposal | 993 | 993 | 993 | 993 |
| Supervision of system design | 300 | 300 | 300 | 300 |
| Ongoing supervision | 600 | 600 | 600 | 600 |
| Maintenance, refinement of procedures | 214 | 214 | 214 | 214 |
| Total | 37,491 | 37,219 | 37,347 | 37,075 |
| Annualized costs | 37,263 | - | 37,119 | - |

[a] ERCO estimates.

## NOTES TO CHAPTER SIX

1. McKeown, J.J., "Sludge Dewatering and Disposal Practices in the U.S. Paper Industry," paper presented at the University of Maine at Orono, August 21, 1978.

2. National Council for Air and Stream Improvement, Technical Bulletin 311, page 18.

3. Dwayne Marshall, speech given at Northeast Regional Meeting held by the National Council for Air and Stream Improvement, November 2, 1978.

4. Econotech Services Limited, *Consequences of Leaching from Pulp and Paper Mill Landfill Operations*, CPAR Secretariat, Department of Fisheries and Environment, Canada, September 1977.

5. Ibid.

6. Gorham International, Inc. *Study of Solid Waste Management Practices in the Pulp and Paper Industry*, EPA, February 1974, page 26.

7. Ibid., page 26.

8. Econotech Services Limited, *Consequences of Leaching from Pulp and Paper Mill Landfill Operations*, CAR Secretariat, Department of Fisheries and nvironment, Canada, September 1977, page 10.

9. Beak Consultants, Ltd., *Technical, Economic and Environmental Aspects of Wet and Dry Debarking*, March 18, page 74.

10. Gorham International, Inc., *Study of Solid Waste Management Practices in the Pulp and Paper Industry*, EPA, February 1974, pp. 25-26.

11. Ibid., page 27.

12. Personal communication between Rob Martin of ERCO and Dick Curry, Technical Director, McMillan, Bloedel Inc.

13. Ibid.

14. American Paper Institute, "Estimated Fuel and Energy Use," 1978.

15. Arthur D. Little, *Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations*, unpublished; "Process Economics," Appendix, pp. H-5 and E-7.

16. Excerpted from "Nature and Behavior of Manufacturing-Derived Solid Wastes of Pulp and Paper Origin, Introduction," preliminary draft, Dwayne Marshall, NCASI.

17. American Paper Institute, "Estimated Fuel and Energy Use."

18. Gorham International, Inc. and Beak Consultants Ltd., op. cit.

19. Personal communication between John Eyraud of ERCO and Mr. Martin of the American Pulpwood Association.

20. American Paper Institute, "Estimated Fuel and Energy Use."

21. Gorham International, Inc., and Arthur D. Little, op. cit.

22. Econotech Services Limited, *Consequences of Leaching from Pulp and Paper Mill Landfill Operations*.

23. McKeown, J.J., "Sludge Dewatering and Disposal Practices in the U.S. Paper Industry."

24. Battelle Columbus Laboratories, *Cost of Compliance with Hazardous Waste Management Regulations*, EPA, May 1978.

25. Arthur D. Little, Inc., *Cost of Pulp and Paper Mill Compliance with Environment Regulations*, EPA, May 1977, Vol. III, p. E-38.

26. Arthur D. Little, Inc., *Cost of Pulp and Paper Mill Compliance with Environment Regulations*, EPA, May 1977, Vol. III.

27. Arthur D. Little, *Preliminary Integrated Assessment of Hazardous Waste Management Regulations*, EPA, October 1978.

## CHAPTER SEVEN

## ECONOMIC IMPACTS ON THE PULP AND PAPER INDUSTRY

This chapter estimates the costs for pulp and paper industry compliance with each of the two regulatory options, for the model and worst-case plants. Current plant revenues are compared to estimated compliance costs for Options A and B in Tables 7-1 and 7-2 respectively. The estimated plant compliance costs are then applied to industry hazardous waste quantities to derive aggregate industry costs which appear in Table 7-3. Finally, Table 7-4 presents a qualitative summary of likely industry impacts on plant closures, job losses, price increases, demand reduction and balance of payments effects.

### 7.1 Model Plant and Worst-Case Impacts

Model plant impacts appear in summary form in Tables 7-1 and 7-2 for Options A and B, respectively. Under Option A regulations, the average plant (unbleached kraft linerboard) has two hazardous waste streams: wastewater treatment plant sludge and its pulping solid wastes (principally rejects from lime burning). There is no bark waste, since the model firm consumes all bark in generating process steam and power. The resulting ash is not considered hazardous under either Option A or B. Fossil fuel consumption is some mix of oil and natural gas, which are assumed to produce negligible solid wastes. RCRA costs are $625,000 or 3.4 percent of the plant's yearly net income. In

**Preceding page blank**

## TABLE 7-1

## IMPACTS ON PULP AND PAPER MODEL PLANTS OPTION A ($000)[a]

| | MODEL PLANT | WORST-CASE PLANT |
|---|---|---|
| Sales | 70,900 | 44,500 |
| Cost of operations | 52,600 | 27,200 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 462 | 627 |
| Administrative costs | 163 | 163 |
| Pretax net income | 17,675 | 16,510 |
| Pretax net income (before RCRA) | 18,300 | 17,300 |
| Percent decline in pretax net income | 3.4% | 4.6% |

[a] ERCO estimates.

## TABLE 7-2

## IMPACTS ON PULP AND PAPER MODEL PLANTS (OPTION B) ($000)[a]

| | MODEL PLANT | WORST-CASE PLANT |
|---|---|---|
| Sales | 70,900 | 44,500 |
| Cost of operations | 52,600 | 27,200 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 245 | 431 |
| Administrative costs | 101 | 101 |
| Pretax net income | 17,954 | 16,768 |
| Pretax net income (before RCRA) | 18,300 | 17,300 |
| Percent decline in pretax net income | 1.9% | 3.1% |

[a] ERCO estimates.

actuality, this percentage will be sensitive to the plant's operating rate (assumed here to be design capacity of 245 days per year), wastewater sludge characteristics, the efficiency of lime burning, and actual construction costs for an onsite landfill. (Site acquisition costs are probably minor since the average medium-sized woodpulp mill's proximity to wooded areas imposes relatively little space constraint.)

The "worst-case" recycled folding boxboard mill has three hazardous waste streams: wastewater treatment sludge, coal ash, and wastepaper reclamation wastes. The fact that the plant burns coal results in the mill's largest solid waste stream, 14,900 MT per year in coal ash. The next largest waste stream is wastepaper reclamation wastes, taken here at 93 kg/MT of product, as indicated in ADL's material balance. In total, then, despite the fact that the mill makes only 118,800 MT product per year versus the average plant's 313,950 MT, its annual solid wastes amount to 28,000 MT. The large waste volume results in total RCRA costs of $790,000 per year. The fraction of net income consumed by RCRA costs is 4.6 percent compared with the 3.4 percent of the model plant.

In Option B, both the average and "worst-case" mills have only one hazardous waste source: chemical pulping wastes and coal ash, respectively. The resulting total RCRA costs decline to $345,000 from $640,000 for the average mill and to $531,000 from $805,000 for the "worst case." These costs amount of 1.9 percent and 3.1 percent of net income, respectively.

## 7.2 Aggregate Cost Impacts

Under Option A, every pulp and paper mill is a hazardous waste generator. There are five Option A hazardous wastes: wastewater treatment sludge, coal ash, chemical pulping wastes, bark, and wastepaper reclamation wastes. The estimated 1977 waste quantity is 8,751,000 MT. Table 7-3 summarizes estimated RCRA costs. Technical disposal costs assume approximately 58 percent of all plants will be able to use onsite disposal. Mills now using municipal treatment plants and small nonintegrated or recycling mills are assumed to be using contractor disposal. This on/offsite breakdown simply assumes that those mills which now have minor solid waste loads (by virtue of their size, nonwood pulping, or use of municipal wastewater treatement plants) will have the most difficulty obtaining the necessary land for onsite disposal. Larger mills,

TABLE 7-3

AGGREGATE COST OF COMPLIANCE FOR THE PULP AND PAPER INDUSTRY

($000)[a]

| | OPTION A | OPTION B |
|---|---|---|
| Technical | 287,400 | 68,600 |
| Administrative | 66,600 | 17,900 |
| Total | 354,000 | 86,500 |
| 1977 production value | 40,200,000 | 40,200,000 |
| Costs as a percent of production value | 0.88% | 0.22% |

[a] ERCO estimates.

wood pulping mills, and mills treating their own wastewater are assumed not to face land constraints. When technical and administrative costs are added, industry costs are $354 million, 0.88 percent of production value.

Under Option B, there are only two hazardous waste streams: coal ash and chemical pumping wastes, for an estimated total of 1,512,000 MT in 1977. The estimated costs are based on an estimated total number of mills which either burn coal, use chemical pulps, or do both. The on/offsite breakdown on which disposal costs are based assumes that all small chemical pulping mills and small nonintegrated mills burning coal will be offsite disposers. (Small chemical pulping mills average only 250 MT per day of product and small nonintegrated mills average only 40 MT per day.) Further, small mills, particularly nonintegrated mills, tend to be located near sources of secondary fiber in metropolitan areas and are most likely to have significant land constraints. Under Option B, total compliance costs are $86,500.

## 7.3 Industry Impacts

The model and worst-case plant impacts indicate relatively small declines in net income for industry firms. As a result, major economic dislocations are not expected. A summary of industry impacts is provided in Table 7-4.

Price increases will ameliorate the effects on income of RCRA disposal costs. The size of the price increase needed for the model and worst-case firms is 0.9 percent and 1.8 percent to cover RCRA Option A costs. The ability to increase prices will vary among industry segments and among

## TABLE 7-4
## SUMMARY OF IMPACTS ON THE PAPER INDUSTRY[a]

| | OPTION A | OPTION B |
|---|---|---|
| Number of generators | 561 | 207 |
| Plant closures | Unlikely | Unlikely |
| Job losses | Unlikely | Unlikely |
| Production cutbacks | Unlikely | Unlikely |
| Price increases | Small | Small |
| U.S. demand reduction | Small | Small |
| Balance of payments effects | None | None |

[a] ERCO estimates.

firms. However, most of the waste streams are common to industry segments and thus at least a partial cost pass-through can be expected.

Mill closures will depend, for the most part, on the number of firms operating at low profit margins, and on differences in their ability to pass through cost increases. The number of plant shutdowns is here estimated to be small. In Table 7-4 plant shutdowns are designated as "unlikely" for both options. The term "unlikely" is defined as meaning that there is a less than 25 percent chance that 10 percent of the industry plants will close. It is noteworthy that, in a study by another EPA contractor, much larger cost increases were expected to cause few mill closings.[1]

Any reduction in U.S. demand is expected to be minor. The elasticity of demand for most paper products is low (see Section 5.2.2). In the event that all costs are passed through, the net reduction should be small.

Balance of payment effects are also expected to be small. Exports represent a minor portion of industry volume, and the small price increases should have minimal balance of trade effects.

## NOTES TO CHAPTER SEVEN

1. Arthur D. Little, Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations, EPA, May 1977. In this study an aggregate cost increase equivalent to an 8 percent price rise was expected to result in 27 mill closings, or roughly 5 percent of industry firms.

## PART III

## GASOLINE SERVICE STATIONS AND AUTOMOBILE REPAIR SHOPS

# CHAPTER EIGHT

## CHARACTERIZATION OF GASOLINE SERVICE STATIONS AND AUTO REPAIR SHOPS

Gasoline service stations and automotive repair shops are viewed together for the purposes of this study for two reasons. First, the waste streams that make them subject to future RCRA regulations are the same--waste motor oil from automobile and truck oil changes as well as waste brake and transmission fluid (also low viscosity motor oils) from transmission and brake fluid changes. Second, the activities that generate these wastes--auto repair and maintenance--are the same for those facilities which actually generate the wastes. In fact, generators of hazardous wastes in the two industries often have more in common with each other than with nongenerators in their respective industries.

Though falling under the same SIC rubrics as gasoline service stations and repair shops, such establishments as mass merchandizers and convenience stores which sell gasoline are not of concern here. However, because data tend to be collected by SIC category, descriptive information on these two industries may include those nongenerating establishments.

The descriptions of the two industries are presented separately below because available data were collected separately. This will also facilitate the development of separate model firms for each industry that will more fully distinguish the different organization and profitability of firms in the two industries. Section 8.1 will present a

**Preceding page blank**

description of the gasoline service station industry while the automotive repair shops will be discussed in Section 8.2.

## 8.1 Gasoline Service Stations

### 8.1.1 Size and Scope of the Industry

### 8.1.1.1 Industry Definition

The definition of gasoline service stations, used throughout Part Three, will include only those establishments that belong to the SIC designation 5541. This category includes those firms that primarily sell gasoline and oil, although they may sell other merchandise and perform repair work. If revenues from other operations exceed those realized from the sale of gas and oil, the firm will not generally be classified as an SIC 5541 establishment. As far as possible, only SIC 5541 specific data have been utilized. However, industry surveys and trade publications do not always adhere so strictly to those confines, and have at times been used to supplement data used for this report.

The goal of this part is to establish the economic impacts of Resource Conservation and Recovery Act (RCRA) legislation on gasoline service stations and automotive repair shops. For the most part, those firms that will be affected are those that change oil or do repair work that generates waste automotive oils. Thus, gas stations that are completely self-service and that do not generate waste oil will be relatively unaffected by RCRA. Unfortunately, most operating statistics for gasoline service stations do not make a distinction between stations that generate waste oil and those that do not. As a result, financial and operating data will apply to all service stations, with distinctions between generators and nongenerators made whenever possible. The analysis of waste oil quantities and economic impacts will apply to those service stations that do generate waste oil.

### 8.1.1.2 Industry Sales

Table 8-1 illustrates industry sales data according to the National Petroleum News for the past 10 years. Total

TABLE 8-1

GASOLINE SERVICE STATION SALES[a]

| | GAS | | OIL | |
|---|---|---|---|---|
| YEAR | TOTAL SALES ($ billion) | TOTAL SALES (MM gal) | QUARTS (MM) | AVERAGE QUARTS PER CAR PER YEAR |
| 1977 | 52.4 | 75,428 | - | - |
| 1976 | 48.0 | 73,417 | 877 | 8.0 |
| 1975 | 43.8 | 77,178 | 1,014 | 9.5 |
| 1974 | 41.0 | 73,818 | 996 | 9.5 |
| 1973 | 34.4 | 72,207 | 961 | 9.5 |
| 1972 | 33.7 | 72,908 | 964 | 10.0 |
| 1971 | 29.2 | 68,821 | 987 | 10.7 |
| 1970 | 27.9 | 65,297 | 1,066 | 12.0 |
| 1969 | 25.9 | 62,047 | 1,046 | 12.1 |
| 1968 | 24.5 | 58,127 | 1,074 | 12.9 |
| 1967 | 22.7 | 54,760 | 1,177 | 14.7 |

[a] 1978 National Petroleum News Factbook Issue.

sales revenues have increased steadily during the period to $52.4 billion in 1977. The total volume of gasoline sales reached a peak of 77.2 billion gallons in 1975 and has not exceeded that level as of 1977. Although the total number of automobiles has increased steadily, the average miles per gallon has increased as well, leading to a decrease in the total gallons sold. Likewise, motor oil sales at service stations have decreased 25 percent from a high of 1.2 billion quarts in 1967 to only 0.9 billion quarts in 1976. This situation is due to two causes. First, the interval between recommended oil changes has been growing. More importantly, a large number of people are choosing to change their own oil, which has meant a shift in the buying patterns for motor oil from service stations to large retail chains and other outlets.

Government mandated increases in average fuel economy for automobile manufacturers' fleets of cars will lead to higher and higher average miles per gallon in the United States. This could offset the expected increase in the total number of automobiles on the road and keep the total gallons of gasoline sold at fairly constant levels through 1985. Motor oil sales at gas stations are likely to continue to decrease, as oil change drain intervals for newer model automobiles continue to increase and retail chains increase their share of the total market for motor oil.

### 8.1.1.3 Employment

The most exact estimates for employment in the gasoline service station industry are those of the 1972 census. In that year, a total of 747,668 persons were employed at 226,459 service stations, an average of 3.30 per station. The average number of employees per station has remained fairly constant since then. The Department of Commerce estimates that per-station employment was 3.35 in 1976. Due to the declining number of stations, total industry employment for 1976 is estimated to be 627,000, a decline of 16 percent from 1972.

Although the average employment per station has remained relatively stable, the average sales have increased at service stations over the period from 1972 to 1976. This implies that the average sales per employee have increased over that period, although much of the change may be attributed to inflation. Table 8-2 displays average product sales per employee in 1972, 1975, and 1976.

As can be seen, employment at service stations has not kept pace with the increases in station sales. The most notable case is the sales of gasoline which have increased approximately 25 percent.

TABLE 8-2

PRODUCT SALES PER EMPLOYEE AT SERVICE STATIONS[a]

| | 1976 | 1975 | 1972 |
|---|---|---|---|
| Gasoline (liters) | 460,230 | 474,410 | 369,300 |
| Oil (liters) | 1,344 | 1,512 | 1,223 |
| Tires | 42 | 38 | 38 |
| Batteries | 24 | 21 | 18 |

[a] 1978 National Petroleum News Factbook Issue.

### 8.1.1.4 Number of Establishments

After reaching a peak of 226,459 establishments in 1972, the number of gasoline stations has been steadily declining.[1] Estimates by the U.S. Department of Commerce published in Franchising in the Economy show the total number of service stations decreased to an estimated 176,450 in 1977 and predict the decline will continue through the end of 1978. Table 8-3 illustrates the approximate number of service stations in the United States from 1967 to 1978.

Whether or not the decline will continue is uncertain. Sources contacted at the offices of National Petroleum News

TABLE 8-3

NUMBER OF GASOLINE SERVICE STATIONS

| YEAR | NUMBER OF SERVICE STATIONS |
|---|---|
| 1978 | 171,000[a] |
| 1977 | 176,450[a] |
| 1976 | 186,400[a] |
| 1975 | 189,480[a] |
| 1974 | 196,130[a] |
| 1973 | 215,880[a] |
| 1972 | 226,459[b] |
| 1971 | 220,000[c] |
| 1970 | 222,000[c] |
| 1969 | 222,200[c] |
| 1968 | 219,100[c] |
| 1967 | 216,059[b] |

[a] U.S. Department of Commerce, Franchising in the Economy 1976-1978.

[b] U.S. Bureau of the Census, Census of Retail Trade.

[c] 1978 National Petroleum News Factbook Issue, p. 103.

and at the U.S. Department of Commerce feel that the decline will continue at least through 1978, while the Department of Energy estimates that the service station population in 1977 was increasing.[2] However, the Commerce Department's estimates are substantiated by the American Petroleum Institute's reports and are generally accepted as being the most reliable.

## 8.1.2 Industry and Market Analysis

### 8.1.2.1 Industry Structure

Under the classification of structure, three aspects will be examined that are seen to provide useful information about the nature of the gas station industry. These are:

1. Concentration ratio among firms.
2. Degree of vertical integration.
3. Barriers to entry.

#### Concentration Ratio Among Firms

Concentration levels on a national scale are miniscule. Since gas stations compete for business only on a local basis, it is only appropriate to consider concentration ratios on that scale. However, even at a local level, it is obvious that concentration levels are quite low and indicate that gas stations are operating in a competitive market. Based on national averages for 1977, a city with 100,000 automobiles has approximately 155 gasoline service stations.[3]

No group of four or eight stations will command a significant share of the market, nor will they be able to exercise any influential market control. Because of this, all service stations are subject to similar competitive pressures within a local area and have little if any control over the market to enable them to force other firms from the market.

Vertical Integration

In economic terms, the retail market for gasoline can be classified as monopolistic competition. In monopolistic competition, certain basic conditions exist.

1. A large number of firms are selling a differentiated product. (Service stations are differentiated by their proximity to customers, credit terms (credit cards), and brand identification.)

2. Each commodity within the product group is a fairly close substitute for every other commodity.

3. Such a large number of sellers is in the market that each expects his competitive maneuvering to go unnoticed by his rivals.

4. Price is the only immediate recourse that each marketer can use in an effort to increase profits.

These qualifications apply very well to gasoline service stations. One gasoline is almost a perfect substitute for another, but the location of each station and brand names provide differentiation. Although it is naive to think that each station assumes that no other stations will match a price decrease, this must be true in part or an operator would see no reason to decrease his price. Finally, a service station has few other short-run methods to improve profits other than manipulating prices.

This situation of monopolistic competition is tempered somewhat by differing degrees of vertical integration.

The most common arrangement for marketing gasoline is when a dealer leases a gas station from a major oil company. This is the situation that will be assumed to exist for the model firm. In this case, the dealer buys his products from and pays rent to the oil company. The dealer's income is represented by the profit remaining after he has covered all of his expenses.

In addition to lessee dealerships, station organization takes other forms. The station can be owned by a major company, who pay all employees a salary and specify operations. In contrast, a dealer can own and operate his own station and obtain gasoline from independent suppliers. Another arrangement is where any individual owns a number of stations and leases them to a number of dealers. Gasoline is then supplied by independent refiners.

## Barriers to Entry

Recent changes in the gasoline service station industry indicate that larger stations have a competitive edge in the industry. As noted in Section 8.1.1.4, the service station population has declined from a high of 226,000 in 1972 to 176,450 in 1977. Much of this decline has occurred fr smaller stations being forced out of business by larger, higher volume stations. As the number of gas stations has gone down, the average volume pumped at stations has gone up. Simultaneously, the margins on sales have gone down. Thus, larger volume stations in general set lower prices, operate on lower margins, and outperform small stations. New stations are increasing in size, raising the capital requirements for new entrants. However, since the number of service stations is still large, the increasing entry requirements will not have a large impact on competition in developed markets. The largest stations require an investment of $250,000. While not small, this investment requirement is not so large as to seriously restrict the abilities of firms to enter the market.

Another concern for market entry is the consideration of supply of gasoline. If a major or semi-major oil company is seeking to open a station, they will also supply the gasoline and other products. An independent dealer must obtain a contractual agreement from an independent refiner for his gasoline. In general, this is not a problem, although the prospects of interrupted or decreased supply may be greater for an independent dealer than for a major branded station.

### 8.1.2.2 Industry Conduct

#### Pricing Policies

The retailing of gasoline is marked by substantial price competition. Because the gasolines sold at various stations are virtually perfect substitutes for each other, price manipulation is virtually the only method to improve one's market position. Individual dealers sometimes choose to use budget prices as a means of entering new territory. Also, gas station economics have become increasingly dependent on high sales volume as the means to increased profits. Both of these practices create the possibility of downward pressure in local gasoline prices and markets.

Before federal price and supply controls of mid-1973, the major brand stations were generally the price leaders. Their prices were undercut by jobbers with branded independent suppliers and private brand marketers. This led to a niche for each type of marketer and margins across the board were high enough to make adequate profits. Since the advent of price and supply controls, this pricing framework has for the most part been changed. Many private branders and branded independent jobbers are paying higher prices for their gasoline than are major brand retailers. An effort to maintain their historic place in the retail market has led to increasing downward pressure on margins. In addition, competitive measures designed to reduce per-gallon operating costs (such as self-service, high volume, or split island stations) have put further pressure on margins. What has resulted is a highly competitive system of setting prices imparting strong pressures to lower per-gallon operating costs so as to cover total average costs. Larger stations, more efficient control of costs, split islands, etc., are all methods used to widen the margin between costs and revenues, and which enable stations to remain price competitive.

#### 8.1.2.3 Industry Performance

The structure and conduct sections above have illustrated the basic organization and methods of doing business in the gasoline service station industry. In the performance section, the discussion will attempt to show how well the structure and conduct combine to realize the goals of efficient service to consumers while maintaining adequate levels of return for the industry.

## Trends in Profits and Prices

As the various retailing strategies mentioned above have been implemented, there has been a steady decline in the margins between the price of gasoline charged to the retailer and the price charged to the consumer. Table 8-4 shows a 17-year history of dealer and consumer prices and the difference as a percentage of the dealer's pretax price. The year 1960 saw the margin at around 30 percent of dealer cost. The margin steadily climbed to around 38 to 39 percent in the period 1967 to 1973. Mid-1973 federal price and supply controls quickly affected the market, as 1974 margins were only 32.4 percent. By 1977 the markup had declined to 19.3 percent. During the same period average prices for the dealer increased from $0.1608/gal to $0.4251/gal, with $0.163/gal of this increase coming in the 2-year period from 1973 to 1975 in the wake of the dramatic increase in world oil prices. Although the upward price trend is continuing, it is not at the rate of increase experienced during 1973 to 1975.

Much of the recent decline in gasoline margins is due to the onset of self-service marketing. Legal in all states except New Jersey and Oregon, self-service generally lowers operating costs so that the margins necessary for adequate profits are lowered. Figure 8-1 shows the growth of self-service gasoline sales in the United States since 1975.

## TABLE 8-4

## GASOLINE PRICES AND MARGINS[a]

| YEAR | DEALER TANK WAGON PRICE (BEFORE TAX) (cents) | SERVICE STATION PRICE (BEFORE TAX) (cents) | MARGIN (cents) | MARGIN (%) |
|---|---|---|---|---|
| 1977 | 42.51 | 50.70 | 8.19 | 19.3 |
| 1976 | 38.99 | 47.44 | 7.45 | 19.1 |
| 1975 | 35.78 | 45.45 | 9.67 | 27.0 |
| 1974 | 30.53 | 40.41 | 9.88 | 32.4 |
| 1973 | 19.48 | 26.88 | 7.40 | 38.0 |
| 1972 | 17.72 | 24.46 | 6.74 | 38.0 |
| 1971 | 18.11 | 25.20 | 7.09 | 39.1 |
| 1970 | 17.68 | 24.55 | 6.87 | 38.9 |
| 1969 | 17.11 | 23.85 | 6.74 | 39.4 |
| 1968 | 16.51 | 22.93 | 6.42 | 38.9 |
| 1967 | 16.31 | 22.55 | 6.24 | 38.3 |
| 1966 | 15.83 | 21.57 | 5.74 | 36.3 |
| 1965 | 15.38 | 20.70 | 5.32 | 34.6 |
| 1964 | 14.82 | 19.98 | 5.16 | 34.8 |
| 1963 | 15.22 | 20.11 | 4.89 | 32.1 |
| 1962 | 15.45 | 20.36 | 4.91 | 31.8 |
| 1961 | 15.80 | 20.53 | 4.73 | 29.9 |
| 1960 | 16.08 | 20.99 | 4.91 | 29.7 |

[a] Platt's Oilgram Service as reported in the 1978 National Petroleum News Factbook Issue.

As can be seen, the growth of self-service marketing has been steady. Whereas early in 1975 only around 14 percent of sales were from self-service pumps, by the end of 1977 the market share approached 40 percent. The price difference between full and self-service gasoline averaged about 4 cents (1978 figures).[4] Since both types of station pay

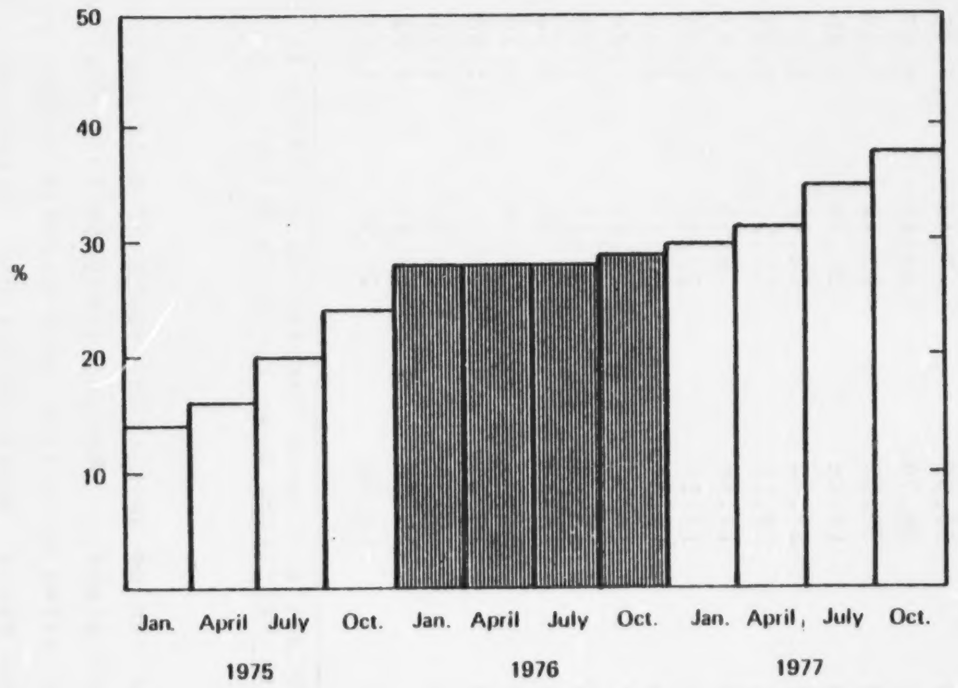


Figure 8–1. Percentage of gasoline sales through self service pumps.
(*1978 National Petroleum News*, Factbook Issue, p. 106.)

the same for gasoline, the self-service marketers are operating on margins approximately 4 cents less than full-service marketers. This puts substantial downward pressure on the margins throughout the industry.

### 8.1.3 Financial Characterization

#### 8.1.3.1 Earnings Trends

Additional data characterizing breakdown of sales dollars are available from a survey of firms in the gasoline service station industry over the period from July 1976 through March 1977. Table 8-5 displays the income data for a 91-firm sample.[5] The 91 firms in the sample registered approximately 7.0 percent of the total sales of the industry in 1976. The operating percentages, expressed with respect to sales, are an average of all individual service stations included in each firm. In this survey by Robert Morris Associates, a firm may consist of one independently owned station or multi-unit firms that own and operate or lease a large number of service stations. Therefore, the data are not reported according to establishment size.

Several points are evident from Table 8-5 that were referred to in the structure and conduct sections of this chapter. First, the cost of operations (87.8 percent of sales) dominate the expense accounts. These costs reflect for the most part the cost of the gasoline to the retailer and the low margins realized on its subsequent sale. Other operating costs are necessarily a small percentage of sales. Rent on business property (included in the operating expenses category) is only a small portion of the expenses (median value of 0.9). Also of note is the profit before tax

## TABLE 8-5

## INCOME DATA FOR GASOLINE SERVICE STATIONS BY PERCENT (JUNE 30 TO SEPTEMBER 30, 1976)[a]

| Asset size ($000) | 0-250 | 250-1,000 | 1,000-10,000 | 10,000-50,000[b] | All |
|---|---|---|---|---|---|
| Number of firms | 25 | 27 | 32 | 7 | 91 |
| Net sales | 100 | 100 | 100 | - | 100 |
| Cost of sales | 84.2 | 84.9 | 83.7 | - | 87.8 |
| Gross profit | 15.8 | 15.1 | 16.3 | - | 12.2 |
| Operating expenses | 13.7 | 13.9 | 14.4 | - | 10.6 |
| Operating profit | 2.1 | 1.2 | 1.9 | - | 1.6 |
| All other expenses (net) | 0.4 | 0 | 0.4 | - | 0.1 |
| Profit before taxes | 1.7 | 1.2 | 1.5 | - | 1.5 |

[a] Robert Morris Associates, Annual Statement Studies, 1977.

[b] Income data were not presented for this category due to the small size of the sample. The data for these stations are included in the overall figures in the last column.

as a percentage of sales. At 1.5 percent for all establishments, this value is typical of retail businesses that have high sales to assets ratios and high inventory turnover rates. The return on sales is not great; the low rate of return on sales must be made up for by pumping a high volume of gasoline.

### 8.1.3.2 Basic Financial Ratios

Table 8-6 displays selected financial ratios based on the same asset sizes and firm sample as the income data above. Each ratio has three values listed. The values

## TABLE 8-6
## FINANCIAL RATIOS (1976-1977 DATA)[a]

| | ASSET SIZE ($000) | | | |
|---|---|---|---|---|
| FINANCIAL RATIOS | 0-250 | 250-1,000 | 1,000-10,000 | ALL |
| Current | 5.1[b] | 2.6 | 1.5 | 1.7 |
| | 1.4[c] | 1.3 | 1.1 | 1.2 |
| | 1.1[d] | 0.8 | 0.7 | 0.8 |
| Quick | 2.0 | 1.0 | 0.9 | 1.0 |
| | 0.7 | 0.6 | 0.5 | 0.6 |
| | 0.5 | 0.3 | 0.3 | 0.4 |
| Cost of sales/ inventory | 64.2 | 44.7 | 49.9 | 51.9 |
| | 19.6 | 27.0 | 31.2 | 30.1 |
| | 8.8 | 15.4 | 17.2 | 15.4 |
| Sales/working capital | 14.4 | 16.6 | 31.8 | 16.9 |
| | 22.8 | 54.0 | 158.5 | 70.0 |
| | 276.5 | -98.3 | -33.8 | -98.3 |
| Sales/net fixed assets | 155.1 | 29.5 | 15.3 | 27.7 |
| | 39.9 | 13.9 | 8.2 | 13.3 |
| | 11.3 | 6.2 | 3.6 | 7.4 |
| Sales/total assets | 12.4 | 7.7 | 6.0 | 7.6 |
| | 6.1 | 5.5 | 4.1 | 5.3 |
| | 4.2 | 3.6 | 2.1 | 3.0 |

[a] Robert Morris Associates, Annual Statement Studies, 1977.

[b] Upper quartile.

[c] Median.

[d] Lower quartile.

represent the upper quartile, the median, and the lower quartile of the values reported.

As firm size increases, several interrelated trends occur. There is a trend away from domination of the balance sheet by current assets and liabilities. In particular, the proportion of assets held as current assets declines even faster than current liabilities, leading to decreasing current and quick ratios (see Table 8-6). This shift occurs mainly due to an increasing percentage of fixed assets and a decline in the percentage of cash and inventories held on the balance sheet. Larger firms are able to hold less of their assets as inventories because they turn over their inventories more rapidly than do small firms. Note in Table 8-6 that the median value for cost of sales/inventory increases with firm size, implying a faster inventory turnover rate.

Although there is marked variation in financial operating ratios as firm size changes, the data presented in Tables 8-6 and 8-7 allow some generalizations to be made about gasoline service stations. Since sales of gasoline (inventory) are the major source of revenue, inventory turnover is rapid.

The Robert Morris survey indicates approximately 75 percent of service stations have quick ratios of 1.0 or below and current ratios of 1.7 or below. These ratios indicate that service stations have to rely upon the selling of inventories to meet short-term obligations.

The dependence upon fast moving gasoline sales enables service stations to realize high sales/fixed assets ratios relative to other industries. Even though profits as a percent of sales are generally small, the high sales to fixed assets ratio enables firms to realize an adequate return on their investment.

### 8.1.4 Model Firm Characterization

Because the number of firms in the gasoline service station industry is so large, it is almost impossible to characterize the industry members sufficiently to accurately assess the impacts on each firm. As an alternative to this time-consuming enterprise, it is convenient to represent the industry by developing model firms that approximate the conditions of actual firms. The majority of these firms will be represented by a single model firm, which will be used to measure "average" impacts. A second "worst-case" model will also be used to focus attention on the most marginally profitable enterprises, i.e., those stations most likely to close due to regulation.

Table 8-7 displays the characterization of the model firm. The justification for the characteristics assigned to the model firm is delineated below.

For the purpose of the analysis, it will be assumed that the model firm operates only one station. In actuality, 97 percent of gasoline service station firms operate only one station.[6]

Financial data in Table 8-7 have been estimated from data supplied by Edwin K. Williams and Co. in the 1978 National Petroleum News Factbook. Williams and Co. provided average regional sales, expenses, and profit data for service stations subscribing to their information service. Their service excludes grocery, towing service, and convenience gas suppliers, making it more representative of stations likely to generate waste oil. The firm believes that they represent the better performers in the industry that can afford to buy their service. Accordingly, the

## TABLE 8-7

## MODEL FIRM CHARACTERIZATION FOR GASOLINE SERVICE STATIONS[a,b]

| | 1977 $ | |
|---|---|---|
| | MODEL FIRM | WORST-CASE FIRM |
| Sales[c] | 344,000 | 246,700 |
| Cost of operations | 327,400 | 243,200 |
| Net income before taxes including compensation of owner | 17,500 | 3,500 |

---

[a] ERCO estimate.

[b] A one-station company has been assumed.

[c] Total gasoline sales for model firm were 429,636 gallons; the worst-case firm pumped 339,252 gal/yr.

regions chosen to represent the model plants were carefully selected to offset this bias.

The mean performance of service stations in Colorado Springs, Colorado was chosen as the representative model. This model pumps 35,803 gal/month - approximately the 1977 national average of 35,600 gal/month. The average net profit for all activities as a function of gasoline sold is $0.032/gal. From annual sales of $344,900, the representative firm nets $13,900 after taxes. This figure has been raised to $17,500 to yield an estimate of pretax net income.

The worst-case firm is represented by the performance of stations in the Valdosta, Georgia, region. This region was a poor performer in the Williams and Co. data base. Only 28,271 gal/month are pumped by this station with an average profit from all operations of $0.01/gal. The worst-case firm's annual net income after taxes of $3,500 from sales of $246,700 is only one quarter that of the average performer. The pretax net income figure remains at $3,500 assuming that exemptions and deductions have already precluded income tax.

## 8.2 Automotive Repair Shops

### 8.2.1 Size and Scope of the Industry

#### 8.2.1.1 Industry Definition

For the purposes of this study, the automotive repair shops that will be considered are covered by SIC classification number 753. Within this category there are five four-digit categories. These are:

7531 - Top and Body Repair Shops - Establishments primarily engaged in the repair of automotive tops, bodies, and interiors.

7534 - Tire Retreading and Repair Shops - Establishments primarily engaged in repairing and retreading automotive tires.

7535 - Paint Shops - Establishments primarily engaged in automotive painting and refinishing. Paint shops of top and body repair establishments are classified in industry 7531.

7538 - General Repair Shops - Establishments primarily engaged in general automotive repair.

7539 - Automotive Repair Shops, not elsewhere classified - Establishments primarily engaged in specialized automotive repair, not elsewhere classified, such as fuel service (carburetor repair), brake relining, front-end and wheel alignment, exhaust system (muffler) repair, radiator repair, and glass replacement and repair. Included in this group are automotive transmission repair shops.

As is the case with gasoline service stations, a firm is classified as an automotive repair shop if it obtains more than 50 percent of its revenue from the sale of its repair services. Thus, most repair facilities in gasoline service stations are not classified as repair shops within the SIC coding system and therefore are not considered here. Their waste problems are discussed as a part of gasoline service stations (see Section 8.1). Similarly, auto repair services offered by automotive dealers or mass merchandisers are not considered in this section.

Although those repair shops in SIC codes 7531, 7534, and 7535 do not primarily do repair work that involves generation of waste oil, many of these shops do perform such work in addition to their specialty. Thus, these firms are considered to be possible generators.

### 8.2.1.2 Industry Sales

Automotive repair shops receipts have grown steadily over the 11 years from 1967 to 1977. Receipts in this period grew from 4 to nearly 14 billion dollars, for an average annual growth of 12.9 percent. However, inflation has had a strong effect on receipts, since the average annual real growth rate has been only 5.07 percent. The total revenue figure is expected to climb by 13.45 percent to $15.6 billion for the year 1978.[7]

In the next several years, the demand for auto maintenance and repair is expected to increase. Implementation of federal legislation requiring warranties on auto emission controls will likely increase automobile repair business activity as state and local inspection and maintenance programs get under way.[8] According to the U.S. Industrial Outlook, receipts are expected to grow at an average 8.7 percent per year over 1977 levels over the next 5 years. However, the growth trend may be balanced somewhat by increasing numbers of do-it-yourself repairs. Of 10,000 households surveyed by the Motor and Equipment Manufacturers Association in 1977, only 43 percent reported that they had paid a mechanic to perform simple uncomplicated work. Only 28 percent used mechanics exclusively and about 19 percent never employ mechanics for their maintenance work. As automobile and repair costs rise, the number of do-it-yourselfers is expected to rise as well.[9]

### 8.2.1.3 Industry Employment

Total paid employees in the automotive repair shop industry approached 238,000 in 1972. In addition to these employees, a total of 53,600 firms operate as individual proprietorships or partnerships without any other employees on the payroll.[10] Thus, census figures do not officially record any employment for these firms. The Bureau of Labor Statistics has estimated the employment in SIC Code 753 for the years 1973 through 1977. According to these estimates, the employment has risen from the 238,000 in 1972 to 302,100 in 1977 at automotive repair shops.[11]

#### 8.2.1.4 Size Distribution of Establishments

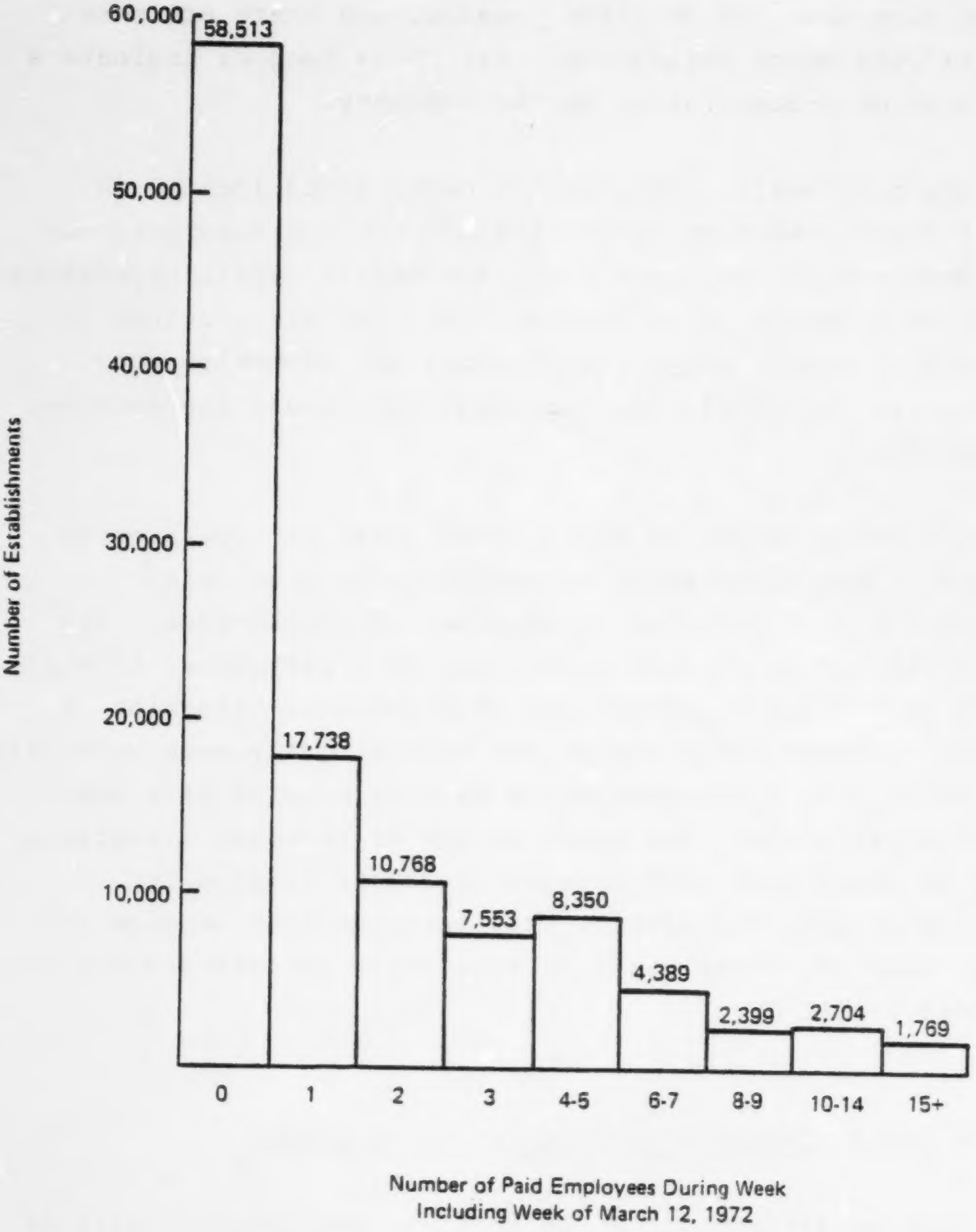
Figure 8-2 shows the size distribution of firms by the number of paid employees. The firms included are those 114,208 firms that were in operation at the end of 1972.[12] As can be seen, over half of the firms had no paid employees and 83 percent of the firms had three paid employees or less. Only 1,769 firms, or 1.5 percent of the total, had 15 or more paid employees.

Clearly, the great majority of automotive repair shops are small businesses that do not operate in conjunction with other firms or company chains. Ninety-eight percent of firms in the 1972 census were single establishment firms that recorded 91 percent of total industry receipts.[13] The other multi-establishment firms include such large firms as "Midas" and "AAMCO," with several hundred establishments each.

### 8.2.2 Industry and Market Analysis

#### 8.2.2.1 Industry Structure

Firm concentration, barriers to entry and the degree of vertical integration in the automotive repair industry are all low. As mentioned in Section 8.2.1.4 above, 98 percent of the auto repair shops are single establishment firms.



Source: U.S. Bureau of the Census. Census of Selected Service Industries, 1972.

Figure 8—2. Size distribution of automobile repair shops by number of paid employees.

They are strictly local, low revenue businesses that rarely employ more than two or three persons, and there are more than 127,000 shops nationwide. All these factors indicate a low level of concentration in the industry.

The many small, individually owned shops located in nearly every community across the country are also evidence that barriers to entry are low. Automobile repair experience and a small amount of capital are all that are required to establish a repair shop. As receipts and expertise grow, shop owners can slowly add equipment and expand the services they offer.

The large number of small shops owned and operated as individual proprietorships or partnerships also helps demonstrate that vertical integration is nonexistent. The chains that exist usually specialize in a particular kind of repair (e.g., AAMCO specializes in automotive transmission service). These large chains are only slightly more vertically integrated than the independents as they usually have their own lines of parts. The small amount of vertical integration which is associated with automobile repair is usually observed at auto dealerships that sell and then service the cars. However, these kinds of automobile dealers are not included in SIC 753.

#### 8.2.2.2 Industry Conduct and Performances

With no significant concentration, barriers to entry or vertical integration, the automotive repair industry can be classified as a competitive industry. However, automotive repair service pricing may not follow a purely competitive model. It may be possible for a given shop to earn some price-setting latitude as a result of a good reputation, a prime location, or, since most shops do little or no advertising, poor price information transfer among customers. Price variations for similar service within a given vicinity are sometimes observed.

During the 1967-76 period, the price of auto repair and maintenance service rose an average of 9 percent per year. Table 8-8 displays a comparison of the price index for automobile repair with that for consumer goods between 1967 and 1976. Price increases in the late sixties and early seventies were lower than those experienced in the mid-seventies. The table also shows that the price index for auto repair services rose nearly 10 percent above the general consumer price index during the same timespan. Both increased costs and demand for auto repair services have contributed to this price trend. Other influencing factors may have been the limited price setting ability of some firms and inflated prices for work done for insurance policy

TABLE 8-8

AUTOMOBILE REPAIR PRICE INDEX VERSUS THE CONSUMER PRICE INDEX[a]

| PRICE INDEX | 1967 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976[b] |
|---|---|---|---|---|---|---|---|---|
| Consumer goods | 100 | 116.3 | 121.3 | 125.3 | 133.1 | 147.7 | 161.2 | 169.2[a] |
| Automobile repair | 100 | 120.6 | 129.2 | 135.1 | 142.2[c] | 156.8[c] | 176.6[c] | 189.7[c] |

[a] 1976 U.S. Bureau of Labor Statistics, Statistical Abstract of the United States.

[b] May 1976.

[c] Estimated by the Bureau of Domestic Commerce.

holders. Prices are expected to continue to climb, fueled by the rising costs experienced by all industries, the anticipated increase in demand for auto repair services, and the predicted drop in the number of full service gas stations (see Section 8.1.2.3).

The analysis of industry data shows that the automotive repair shop industry is characterized by a large number of small, personally owned establishments that do well just to turn a profit. Amid many consumer complaints about unnecessary repair work and high charges, this may seem paradoxical. Much of it can be explained, however, by remembering that a great deal of automotive repair work is done by automobile dealers, gasoline service stations and mass merchandisers. These establishments are not classified as SIC 753 and thus their statistics do not show up here. The repair work performed by SIC 753 repair shops is more likely to be the less desirable work and business will not be as regular as that experienced by a gas station or automobile dealer. Thus, the small independent auto repair shops are at a disadvantage compared to other repair facilities that have another line of work to support them.

### 8.2.3 Financial Characterization

#### 8.2.3.1 Earnings Trends

Table 8-9 presents financial statistics for auto repair shops as compiled by Robert Morris Associates. The data are taken from a 93-firm sample of firms in the SIC 7538 (general automotive repair shops) classification.[14] The sample firms registered approximately 6 percent of industry sales in 1977. As is the case with the gasoline service station

### TABLE 8-9

### INCOME DATA - AUTOMOTIVE REPAIR SHOPS (JUNE 30, 1976 TO MARCH 31, 1977)[a]

| | ASSET SIZE ($000) | | | |
|---|---|---|---|---|
| | 0-250 | 250-1,000 | 1,000-10,000[b] | ALL |
| Number of firms | 64 | 23 | 6 | 93 |
| Net sales | 100.0 | 100.0 | - | 100.0 |
| Operating expenses | 94.9 | 97.4 | - | 95.7 |
| Operating profit | 5.1 | 2.6 | - | 4.3 |
| All other expenses (net) | 1.5 | 0.2 | - | 0.0 |
| Pretax net income | 3.7 | 2.8 | - | 4.3 |

[a] Robert Morris Associates, Annual Statement Studies, 1977.

[b] Income data were not presented for this category due to the small size of the sample. The data for these stations are included in the overall figures in the last column.

characterization, a firm in the sample may consist of one independently owned shop or may be part of a multi-unit chain. The operating percentages, expressed with respect to sales, are an average of all individual service stations included in each firm.

Although not reported by the Robert Morris data, the cost of sales for auto repair shops is only around 50 percent of sales, in contrast to the 88 percent figure for gasoline service stations.[15] This reflects the fact that automobile repair shops have higher overhead costs relative to receipts. Because of this, other expenses are increased in their share of the total costs of doing business.

Table 8-9 shows that the profit before taxes of automobile repair firms in the sample averaged 4.3 percent of sales. The 64 firms in the smallest asset size category averaged only 3.7 percent of sales as net profit before taxes. It appears that modest profit margins are the rule in this industry.

#### 8.2.3.2 Financial Ratios

Table 8-10 shows selected financial ratios for the automobile repair shop sample used in Table 8-9. Each ratio has three values listed. The values represent the upper quartile, the median, and the low quartile of the values reported.

The current and quick ratios for the firms in the sample do not vary appreciably with the asset size of the firm. The median current ratio is 1.4 and the median quick ratio is 0.7. These ratios are somewhat lower for business enterprises. However, in general terms, they indicate only that repair shops must maintain sales volume in order to meet their obligations.

### 8.2.4 Model Firm Characterization

The model firms for automotive repair shops are characterized in Table 8-11. As with gasoline service stations, almost all firms (98 percent) are single facility establishments. Accordingly, the model firm operates only a single shop.

## TABLE 8-10

## FINANCIAL RATIOS FOR AUTO REPAIR SHOPS (1976-77 DATA)[a]

| FINANCIAL RATIOS | ASSET SIZE ($000) | | |
|---|---|---|---|
| | 0-250 | 250-1,000 | ALL |
| Current[e] | 2.1[b] | 1.8 | 2.1 |
| | 1.4[c] | 1.4 | 1.4 |
| | 1.0[d] | 1.2 | 1.0 |
| Quick[f] | 1.2 | 1.3 | 1.2 |
| | 0.7 | 0.8 | 0.7 |
| | 0.4 | 0.6 | 0.4 |
| Sales/working capital | 10.1 | 8.2 | 9.5 |
| | 23.5 | 14.1 | 18.0 |
| | 339.0 | 21.7 | 142.9 |
| Sales/net fixed assets | 30.2 | 40.9 | 31.2 |
| | 14.6 | 17.3 | 14.5 |
| | 4.8 | 8.6 | 6.3 |
| Sales/total assets | 4.9 | 3.4 | 4.2 |
| | 3.2 | 2.9 | 3.0 |
| | 2.0 | 2.4 | 2.0 |

---

[a] *Annual Statement Studies*, Robert Morris Associates, 1977

[b] Upper quartile.

[c] Median.

[d] Lower quartile.

[e] The ratio of current assets over current liabilities.

[f] The ratio of current assets net of inventories over current liabilities.

## TABLE 8-11

## MODEL FIRM CHARACTERIZATION AUTOMOTIVE REPAIR SHOPS[a]

| | 1977 $ | |
|---|---|---|
| | MODEL FIRM | WORST-CASE FIRM |
| Sales | 80,000 | 40,000 |
| Cost of operations | 69,000 | 32,500 |
| Compensation of proprietor | 8,100 | 6,000 |
| Net income before taxes | 2,900 | 1,500 |
| Net income and proprietor compensation before taxes | 11,000 | 7,500 |

[a] ERCO estimates.

The model firm generated 1977 annual sales of $80,000 - the appropriate mean in 1972[16] multipled by a 1.44 inflation factor.[16,17] The cost of operation has been estimated at a level sufficient to generate a net profit before taxes of 3.7 percent of sales. A "compensation of officers" of $8,100 was included as well. The 3.7 percent profit figure comes from the mean of the 64 small automotive repair shops sampled by Robert Morris Associates in their 1977 Annual Statement Studies. The $8,100 compensation of officers is included here because the formulation of the model plant used statistics that separated this figure out from the income of the business. The figure of 10.1 percent was obtained from the mean compensation as a percentage of sales for automotive repair firms with assets under 100,000 (and average receipts of $100,000).[18] Thus, a figure absent from the model plants for gasoline services stations - net profit and compensation of owners before taxes - is also given here. This statistic is the best estimate of total income derived by the owner of an automotive repair shop.

The estimates for the worst-case facility are similar to those for the model facility. Sales are reduced to $40,000. This figure is 50 percent of the sales of the model firm. Deflated to 1972 dollars it places the sales of the firm within lowest quarter of repair shops that maintained a payroll in 1972.[19] The cost of operations was estimated to again yield a 3,7 percent pretax profit on sales with provision for an annual salary of $6,000 for the proprietor.

# NOTES TO CHAPTER EIGHT

1. U.S. Bureau of the Census, *U.S. Census of Retail Trade*, 1972.

2. National Petroleum News, February 1978, p. 19.

3. $1977 - \frac{\text{176,450 services stations}}{\text{114,173,000 automobiles}} \times 100{,}000 = 155$

4. *Lundberg Letter*, June 2, 1978, p. 1.

5. Robert Morris Associates, *Annual Statement Studies*, *1977*.

6. U.S. Bureau of the Census, *Census of Selected Service Industries*, 1972.

7. U.S. Industrial Outlook, 1978, p. 451.

8. U.S. Industrial Outlook, 1978, p. 451.

9. U.S. Industrial Outlook, 1978, p. 450.

10. U.S. Bureau of the Census, *Census of Selected Service Industries, 1972*.

11. Bureau of Labor Statistics, *Report of Employment and Earnings*, 1973-1977.

12. According to the *Census of Selected Service Industries*, 13,054 firms contributed to census figures, yet were not in operation on December 31, 1972. Thus, Table 8-9 has employment figures for only 114,208 firms.

13. U.S. Bureau of the Census, *Census of Selected Service Industries*, 1972.

14. *Annual Statement Studies*, Robert Morris Associates, 1977.

15. *Almanac of Business and Financial Ratios*, Leo Troy, 1978, p. 319.

16. U.S. Bureau of the Census, *Census of Selected Service Industries*, 1972.

17. U.S. Bureau of Labor Statistics, Automobile Repair Price Index, *Statistical Abstract of the United States*.

18. Almanac of Business and Financial Ratios, Leo Troy, 1978, p. 319.

19. 23.1 percent of firms with a payroll had receipts of $30,000 or less in 1972 according to U.S. Census of Retail Trade, 1972.

# CHAPTER NINE

## WASTE CHARACTERIZATION

This chapter focuses on the waste streams generated by gasoline service stations and auto repair shops. The distinction is made between those waste streams that will be affected by the proposed RCRA regulations and those that will not, in order to be able to perform the economic impact analysis in Chapter Ten. Chapter Nine includes a description of basic characteristics, sources of and quantities generated, current disposal practices, and RCRA-imposed changes in disposal practices.

### 9.1 Waste Characteristics

#### 9.1.1 Identification

The major waste stream from service stations and auto repair shops is waste oil. The waste oil is taken primarily from automobile crankcases during oil changes, but significant amounts of waste hydraulic oil from automatic transmissions are also generated. The main focus of this chapter is on these waste oils. Other waste streams are discussed briefly in later sections.

#### 9.1.2 Characteristics of Waste Oil

The major portion of automotive waste oil consists of waste oils drained from automotive crank cases.

**Preceding page blank**

Less than 15 percent of the total waste oil volume consists of transmission fluids, gear lubricants, and minor amounts of kerosene or other solvents used in the service station or repair shop.[1]

Virgin lubricating oils are affected by contaminants picked up during circulation through the crankcase of the automobile. A principal contaminant is lead from gasoline. Virgin oil contains virtually no lead. Used waste oil may contain as much as 20,000 ppm (2 percent) of lead.[2] Other metals from gasoline, as well as fines from engine wear, contribute to metal impurities in waste oil. The most common metals in addition to lead are zinc, iron, and magnesium. Small amounts of copper, aluminum, and chromium may also be evident.[3]

The characteristics of several samples of used waste oil are shown in Table 9-1. Also, Table 9-2 compares the characteristics of new oil with a sample of the same oil after use. The lead content for the various waste oil samples varies from 4,720 ppm (0.47 percent) to 22,000 ppm (2.2 percent). The lead levels in waste oil are far above the limits specified in RCRA (Options A and B) as acceptable for wastes. As a result, waste oil will be considered to be a hazardous waste in this report.

In some cases, used oils have also been found to contain other potentially toxic or carcinogenic compounds. Under the broader definition of toxicity in RCRA Option A, a number of these compounds would be restricted. Some of the substances found in waste oil include polychlorinated biphenyls (PCB); 2,3,7,8-tetrachlorodibenzodiorin; 2,4,5-trichlorophenol; and polycyclic aromatic hydrocarbons. The extent to which such chemicals may be found is not known, but such occurrences appear likely to be the exception.[4]

## TABLE 9-1

## ASSAYS OF AUTOMOTIVE CRANKCASE DRAIN OILS

| CHARACTERISTICS | A[a] | B[a] | C[b] | D[c] | E[c] | F[c] |
|---|---|---|---|---|---|---|
| Flash point (°F) | 325 | 400 | 215 | 204 | 427 | 360 |
| Viscosity at 100° F, SSU | 441 | 549 | 248 | 255 | 435 | 340 |
| Viscosity at 210° F, SSU | 71.2 | 95.8 | 56.4 | 56.7 | 72.4 | 61.7 |
| Viscosity index | 149 | 196 | 166 | 168 | 158 | 145 |
| Gravity (°API) | 23.1 | 22.0 | 24.6 | 25.03 | 20.0 | 24.34 |
| Pour point (°F) | <-35 | <-30 | - | -35 | -25 | -30 |
| Ash (%) | - | - | 1.81 | 1.87 | 2.67 | 1.60 |
| Water by vol. (%) | - | - | 4.4 | 2.8 | 5.7 | 7.9 |
| Nitrogen weight (%) | 0.21 | 0.17 | - | 1.104 | 0.094 | 0.068 |
| Sulfur weight (%) | 0.31 | 0.28 | 0.34 | 0.39 | 0.38 | 0.36 |
| Oxygen weight (%) | 1.80 | 2.25 | - | - | - | - |
| Zinc (ppm) | 690 | 670 | 800 | 1,201 | 1,267 | 1,000 |
| Lead (ppm) | 15,000 | 22,000 | 11,100 | 4,720 | 13,885 | 7,070 |
| Barium (ppm) | - | - | 600 | 180 | 693 | 286 |
| Calcium (ppm) | - | - | 1,700 | 1,175 | 1,480 | 1,245 |
| Phosphorus (ppm) | - | - | 900 | 1,080 | 1,118 | 889 |
| Iron (ppm) | - | - | 360 | 137 | 306 | 200 |

---

[a] ESSO results reported in Norman Weinstein, Waste Oil Recycling and Disposal, Recon Systems, Inc., August 1974.

[b] API results reported in Norman Weinstein, Waste Oil Recycling and Disposal, Recon Systems, Inc., August 1974.

[c] M.L. Whisman et al., Waste Lubrication Oil Research, Part I, Bartlesville Energy Research Center, Bartlesville, Oklahoma, June 1975.

## TABLE 9-2

## COMPARISON OF NEW AND USED OIL PROPERTIES

| | NEW OIL | USED OIL |
|---|---|---|
| Flash point (° F) | 355 | 220 |
| Viscosity at 100° F, SUS | 280 | 265 |
| Viscosity at 210° F, SUS | 61.2 | 58.0 |
| Gravity (° API) | 30.2 | 26.2 |
| Pour point (°F) | -35 | -35 |
| Ash (%) | 1.13 | 2.82 |
| Nitrogen weight (%) | 0.021 | 0.091 |
| Sulfur weight (%) | 0.30 | 0.32 |
| Carbon residue | 1.1 | 4.3 |
| Gasoline dilution | 0.4 | 3.0 |
| Metals concentration (ppm) | | |
| Zinc | 359 | 461 |
| Lead | 0 | 10,420 |
| Barium | 162 | 150 |
| Calcium | 3,430 | 3,600 |
| Phosphorus | 470 | 600 |
| Iron | 1 | 149 |

[a] M.L. Whisman et al., Waste Lubricating Oil Research - Some Innovative Approaches to Reclaiming Used Crankcase Oil, Bartlesville Energy Research Center, Bureau of Mines, 1974.

Waste hydraulic oil, which is used for transmission fluids, is a listed hazardous waste under RCRA Section 3001 (Option B). Less work has been done on defining the characteristics of used hydraulic oil than has been done for used crankcase oil, due perhaps to the smaller volumes generated. Waste transmission fluids do not become contaminated with lead through contact with gasoline, as do motor oils. However, some hydraulic oils include barium-containing additives.[5] Barium is listed as one of the parameters in the EPA Interim Primary Drinking Water Standards, with a maximum permissible specified level of 1.0 mg/l.

Several of the physical properties of waste oil shown in Table 9-1 affect the ease with which they can be used or reprocessed. Oils with high water content generally need to be dehydrated before reuse. Ash or sediment content need also be removed or reduced.

### 9.1.3 Other Waste Streams

In addition to waste oils, gasoline service stations generate other waste streams that may be potentially hazardous. Those identified by this study are antifreeze solutions and waste solvents, and batteries. As explained below, none constitute a separate waste stream that will be affected by currently proposed RCRA legislation in addition to the waste oil regulation.

#### 9.1.3.1 Antifreeze

A potentially hazardous waste stream generated by service stations is antifreeze flushed out of automobile radiators. Most antifreeze is allowed to run into sewer drains and thus would come under the controls established by the Clean Water Act. However, some stations or repair shops may allow uncontrolled runoff onto nearby land areas.

The ethylene glycol base in antifreeze solutions is toxic to humans and is also contaminated by metals worn off the automobile cooling system. However, the material is not currently listed in the Section 3001 regulations as a hazardous waste. An examination was undertaken to determine whether or not the material should probably be considered as hazardous according to RCRA standards.

The toxicity requirements of RCRA Section 3001 specify that a waste stream not have more than 10 times the metal content of the EPA Primary Safe Drinking Water Standards. Used antifreeze contains significant amounts of copper and can also include small iron quantities. However, these metals are included only in the Secondary Drinking Water Standards. Used antifreeze solutions are not therefore hazardous according to the definition of toxicity in Section 3001 for Option B.

An additional definition of toxicity is included in the Option A version of Section 3001. In that version, a hazardous waste is any substance which has a calculated human LD50 (a dosage lethal to 50 percent of a population) of less than 800 mg/kg at greater than a specified concentration. The ethylene glycol human LD50 value is 1500 mg/kg so the material is also nonhazardous by this definition.[6]

The materials used to flush radiators are more highly toxic than the antifreeze itself. Radiator flushes commonly include rust inhibitors such as sodium chromate and sodium metasilicate. The human LD50 values for these substances are 32 mg/kg and 205 mg/kg respectively. However, very small quantities of these materials are used. Normal practice is to use one pint of radiator flush when chemical flushing is needed. The chemical flush would be diluted many times if it is collected with the large water quantities used in flushing operations. Furthermore, relatively few cars require the use of chemical flushes. One garage owner who specialized in radiator work estimated that he used these materials on only 20 percent of the cars serviced. Due to the small quantities of these materials, and the large extent of dilution in use, these materials will not be examined as a separate waste source.

### 9.1.3.2 Solvents

In service stations and repair shops, some solvents are used for degreasing parts. A portion of the industry continues to use gasoline for parts cleaning, but solvents appear to be used much more commonly. The methods of disposing of the used solvents (or gasoline) are described below. The information is based on an ERCO survey of stations and repair shops in Boston and Washington, D.C.

The principal disposal methods are the following:

1. Used solvent is captured and recycled to a solvent reclaimer. Roughly one-half of the firms contacted had contracts with a solvent reclaimer.

2. Used solvent or gasoline is dumped into the waste oil holding tank. Dumping into the waste oil tank appeared to be as common as the first methods.

3. Solvent is dumped into the sewer. Few firms appear to dispose of the material in this manner. However, the telephone survey results are probably biased downward, because station owners are aware of regulations on sewer disposal.

The quantities of used solvent range from a few gallons a month for a station that does little car servicing to 15 gallons a month.

Either of the first two methods indicates that solvent disposal is not a separate waste problem. These procedures appear to represent 80 percent or more of industry practice. If sewer disposal is used, the waste stream would be controlled by other regulations. As a result, these waste streams have not been analyzed further for the economic impact analysis.

### 9.1.3.3 Batteries

A typical battery contains over 11 kilograms of lead. As a result, many firms find it advantageous to recover the lead from used batteries. As a consequence, almost all service stations and garages appear to sell their old batteries to scrap dealers, based on contacts with industry personnel. The scrap dealers then sell the batteries for lead recovery. Some batteries are, however, probably disposed of with general refuse.

It will be assumed that batteries sent to recovery facilities will not be regarded as hazardous wastes by RCRA. This assumption is consistent with other RCRA interpretations made in this report. Specifically, it appears consistent with the judgment that steel drums which are being sent to reconditioners will not be considered hazardous wastes. Thus, the disposal of used batteries by service stations and garages is not seen to be affected by RCRA legislation.

## 9.2 Model Plant Waste Oil Quantities

In order to apply the economic impact analysis to gasoline service stations and automobile repair shops, a "model plant" approach has been chosen in order to determine impacts upon a typical establishment. From there, the impacts as they apply to more and less highly impacted firms can be estimated. This section will establish the "typical" waste quantities to be used for the economic impact analysis (see Chapter 10).

### 9.2.1 Gasoline Service Stations

Based upon discussions with gasoline service station owners and waste oil collectors, an average gasoline service station will generate approximately 4,000 liters of waste oil per year. Based upon a 6-day average work week, a station needs to perform three oil changes per day to obtain 4,000 liters over the course of a year. This estimate (three changes a day) will be used for the model station waste quantity. Table 9-3 displays the monthly and yearly amount of waste crankcase oil generated (in both liters and kilograms) based upon an estimate of three oil changes per day, 6 days per week. Since a majority of service stations do not do transmission work, the model plant was assumed to not be generating hydraulic oils.[7] If this assumption were to be modified, then the amount of waste oil for the model station should be increased 25 percent.[8]

TABLE 9-3

GASOLINE SERVICE STATIONS
MODEL PLANT WASTE CRANKCASE OIL GENERATION

| PER MONTH | | PER YEAR | |
|---|---|---|---|
| LITERS | KILOGRAMS[a] | LITERS | KILOGRAMS |
| 331.5 | 295 | 3,978 | 3,540 |

[a] Based upon average 0.89 specific gravity.

For the worst-case station, the waste oil quantity was kept unchanged from that of the model plant. However, the worst-case station has a lower sales volume. Thus the rate of waste oil generation was increased slightly (approximately 25 percent). The characteristics of the model and worst-case firms were described previously in Section 8.1.4.

### 9.2.2 Automotive Repair Shops

Because many automotive repair shops specialize in certain types of repair and do only infrequent oil changes, the average number of oil changes per day is somewhat less for repair shops than for gasoline service stations. For the model plant formulation, it was assumed that a typical automotive repair shop does only nine oil changes per week. It also does some transmission work. These estimates are based on discussions with industry personnel. Table 9-4 displays the waste oil quantities generated by the model repair shop.

TABLE 9-4

MODEL PLANT WASTE OIL QUANTITIES
AUTOMOTIVE REPAIR SHOPS[a]

| | PER MONTH | | PER YEAR | |
|---|---|---|---|---|
| | LITERS | KILOGRAMS | LITERS | KILOGRAMS |
| Crankcase oil | 165.8 | 147.5 | 1,989 | 1,770 |
| Hydraulic oil | 86.7 | 73.7 | 1,040 | 884 |
| Total | 252.5 | 221.2 | 3,029 | 2,654 |

[a] ERCO estimate, based on an assumption of 9 oil changes per week and 2 major transmission jobs per week.

The same amount of waste oil was assumed to be generated at the worst-case repair shop. The worst-case firm is, however, approximately half the size of the model firm. As part of the worst-case formulation, it was assumed that the worst-case firm had a higher relative waste generation rate, and thus may be more highly impacted.

## 9.3 Aggregate Waste Quantities

### 9.3.1 Gasoline Service Station Wastes

### 9.3.1.1 Waste Crankcase Oil Generated at Service Stations

The most generally accapted figures for waste oil quantities are those published in a 1974 study for the United States Environmental Protection Agency, Waste Oil Recycling and Disposal.[9] These estimates rely on sales figures of motor oil to extrapolate the amount of motor oil that ends up as waste oil.

In the EPA study, it is assumed that 70 percent of all motor oil sales at gasoline service stations are used for changes, and that 90 percent of this amount is recovered as drainings. Thus, a "recovery factor" of 63 percent (0.7 x 0.9) of the sales of motor oil at service stations yields an estimate for the amount of waste oil from service stations. Table 9-5 presents estimates of the amount of waste oil generated by gasoline service stations based upon this method.

A more direct method of calculating service station waste oil is to utilize estimates for the number of oil

TABLE 9-5

## ESTIMATES OF WASTE CRANKCASE OIL GENERATED BY SERVICE STATIONS BASED UPON A 0.63 RECOVERY FACTOR

| YEAR | SERVICE STATION SALES (MM liters)[a] | | RECOVERY FACTOR[b] | | WASTE OIL (MM liters) |
|---|---|---|---|---|---|
| 1976 | 839.4 | x | 0.63 | = | 528.8 |
| 1975 | 959.5 | x | 0.63 | = | 604.5 |
| 1974 | 942.5 | x | 0.63 | = | 593.7 |
| 1973 | 909.4 | x | 0.63 | = | 572.9 |
| 1972 | 914.2 | x | 0.63 | = | 575.9 |
| 1971 | 934.0 | x | 0.63 | = | 588.4 |

[a] 1978 National Petroleum News Factbook for 1972-76; 1977 Factbook for 1971.

[b] Waste Oil Recycling and Disposal, Norman J. Weinstein, Recon Systems, Inc., 1974.

changes performed by service stations. Table 9-6 presents the number of oil changes and the amount of waste oil generated (calculated on a basis of 4.25 liters of waste oil per change).[10] These figures are based upon a direct survey of a segment of the service station market every 3 years by Service Station Management Magazine. Entitled "Service Job Analysis," the survey seeks to determine the number of oil changes performed. The survey results are weighted by the number of firms per geographic area and by the dollar volume of respondents, and then projected to national estimates. Also estimated are the number of oil changes performed by independently owned repair shops, new car and truck dealers, and fleets of 25 or more vehicles that perform their own service work (see Table 9-11).

## TABLE 9-6

## OIL CHANGES AND WASTE CRANKCASE OIL GENERATED BY GASOLINE SERVICE STATIONS

| YEAR | OIL CHANGES[a] (mm) | | LITERS OF WASTE OIL PER CHANGE | | WASTE OIL (MM liters) |
|---|---|---|---|---|---|
| 1978[b] | 115.0 | x | 4.25 | = | 488.6 |
| 1975 | 114.4 | x | 4.25 | = | 486.2 |
| 1972 | 138.2 | x | 4.25 | = | 587.4 |
| 1969 | 147.4 | x | 4.25 | = | 626.5 |

[a] "Service Job Analysis," Service Station Management, 1975, 1972, 1969.

[b] Preliminary estimate based upon one-half the normal sample size, obtained by telephone communication from Service Station Management

As can be seen, the two methods yield very similar estimates for the quantity of waste oil generated in 1969 and 1972. However, the 1975 estimate derived from the number of oil changes is 20 percent lower than the estimate derived from employing a recovery factor of 0.63 to the sales of motor oil. This difference is equivalent to a recovery factor of 0.51 for 1975 sales of waste oil at gasoline service stations.

For this study, the survey-based estimates of waste oil use will be regarded as the most reliable. Recent trends indicate that increasing numbers of people are changing their own oil, and it seems likely that the recovery factor of 0.63 at service stations is unrealistically high for 1975 and later years. The trend toward do-it-yourself oil changes would suggest that a greater percentage of the service station motor oil is sold only for make-up oil. Thus, to formulate estimates for the current amounts of waste oil, a recovery factor of 0.51 will be applied to the sales of motor oil at gasoline service stations.

### 9.3.1.2 Crankcase Oil Returned to Service Stations

In addition to waste oil generated directly at service stations, some waste oil that individuals generate when they change their own oil is returned to service stations for disposal. However, most of the waste oil generated by individuals is disposed of in backyards, alleys, empty lots, sewers, drains, etc.

Estimation procedures based on motor oil sales can be used to derive the volume of oil returned to stations. Estimates of the relative sales of motor oil from retail outlets other than gasoline service stations were made by National Petroleum News for 1971 and 1978. The sales volume, expressed as a percentage of service station sales, rose from 62 percent in 1971 to 196 percent in 1978.[11] For 1978, the quantity of oil sold is estimated at 1.88 billion liters.[12] For estimation purposes, 15 percent of the waste oil from "do-it-yourself" is assumed to be taken to service stations for disposal. This percentage is an assumption based on conversations with station operators. Other investigators have used percentages as high as 35 percent (see the reference cited in Note 2 at the end of this chapter). Table 9-7 displays estimated amount of waste oil returned to gas stations for the years 1975 through 1978.

### 9.3.1.3 Waste Hydraulic Oil Quantities from Gasoline Service Stations

A limited number of gasoline stations engage in transmission repair work that generates waste hydraulic oils. According to the "Service Job Analysis," 4.5 percent of gasoline service stations with service bays did transmission overhauls and 38 percent did transmission drain and fills in

## TABLE 9-7

## WASTE CRANKCASE OIL RETURNED TO SERVICE STATIONS[a]

| YEAR | RETAIL STORE SALES (MM liters) | AMOUNT RECOVERED IN OIL CHANGES (MM liters) | | PERCENT RETURNED TO STATIONS | TOTAL RETURNED TO GAS STATIONS (MM liters) |
|---|---|---|---|---|---|
| 1978 | 1,877.7 | 1,182.9 | x | 15 | 177.4 |
| 1977 | 1,424.0 | 897.1 | x | 15 | 134.6 |
| 1976 | 1,185.8 | 664.8 | x | 15 | 90.7 |
| 1975 | 1,156.2 | 585.9 | x | 15 | 87.9 |

[a] ERCO estimates. Assumes 15 percent of waste oil is returned to stations. The amount recovered in oil changes (second column) in 1977 and 1978 is based on a 63% recovery factor (see p. 9-11). Figures for earlier years are from "Service Job Analysis," Service Station Management.

[b] "Can Stations Plug the Leaks?," Merrill O'Brien, National Petroleum News, April 1978, p. 50; 1977 and 1978 National Petroleum News Factbook issues.

1975. Table 9-8 displays estimates of the waste hydraulic fluid generated at gasoline service stations, based on 10 liters of fluid per repair.

The estimates in Table 9-8 for 1976-1978 have been adjusted from the 1975 estimate from the "Service Job Analysis" based upon the number of automobiles registered in the United States each year.[13]

### 9.3.1.4 Total Waste Oil Quantities from Gasoline Service Stations

Table 9-9 summarizes the total waste oil available for disposal by gasoline service stations. The total includes

## TABLE 9-8

## WASTE HYDRAULIC OIL - GASOLINE SERVICE STATIONS

| YEAR | TOTAL OVERHAULS AND DRAINS (MM) |  | LITERS PER DRAIN |  | HYDRAULIC OIL (MM liters) |
|---|---|---|---|---|---|
| 1978 | 2.99[a] | x | 10 | = | 29.9 |
| 1977 | 2.89[a] | x | 10 | = | 28.9 |
| 1976 | 2.80[a] | x | 10 | = | 28.0 |
| 1975 | 2.71[b] | x | 10 | = | 27.1 |

[a] ERCO estimates based upon increase in automobile population and 1975 figure.

[b] "Service Job Analysis," Service Station Management, 1975.

## TABLE 9-9

## TOTAL WASTE OIL FROM GASOLINE SERVICE STATIONS (MM liters)[a]

| YEAR | CRANKCASE OIL GENERATED AT SERVICE STATIONS | CRANKCASE OIL RETURNED TO SERVICE STATIONS | HYDRAULIC OILS GENERATED AT SERVICE STATIONS | TOTAL |
|---|---|---|---|---|
| 1978 | 488.6 | 177.4 | 29.9 | 695.9 |
| 1977 | 438.7 | 134.6 | 28.9 | 602.2 |
| 1976 | 428.1 | 90.7 | 28.0 | 546.8 |
| 1975 | 486.2 | 87.9 | 27.1 | 601.2 |

[a] ERCO estimates.

the waste oil returned by those who perform their own oil changes and waste hydraulic oils generated from transmission repair.

### 9.3.2 Auto Repair Shops Waste Oil

A survey of oil changes by automotive repair shops, similar to that for service stations, was performed by Service Station Management magazine for the years 1972, 1975, and 1978. The waste oil quantities estimates are shown in Table 9-10. It was assumed that 4.25 liters of oil are recovered with each oil change. Transmission work at auto repair shops is a major source of waste hydraulic oils. The estimates of the quantity of hydraulic oil generated are also presented in Table 9-10.

### 9.3.3 Total Automotive Waste Oil - 1978

Although gasoline service stations (SIC 5541) and automobile repair shops (SIC 753) are major generators of waste

TABLE 9-10

TOTAL WASTE OIL FROM AUTOMOTIVE REPAIR SHOPS
(MM liters)

| YEAR | WASTE OIL | HYDRAULIC OIL | TOTAL |
|---|---|---|---|
| 1978 | 155.0 | 51.1 | 206.1[a] |
| 1975 | 92.6 | 46.2 | 138.8[b] |

[a] ERCO estimates.

[b] "Service Job Analysis," Service Station Management, 1975.

oils, new car and truck dealers and fleets of automobiles or trucks with captive repair and maintenance are also significant generators of waste crankcase and hydraulic oils. These generators tend to have a relatively large amount of waste oil per establishment. Table 9-11 shows estimates of the waste oil generated from gasoline service stations, auto repair shops, new car and truck dealers, and fleets in 1978.[14] The total automotive waste oil from all four sources in 1978 is estimated at 1.263 billion liters.

TABLE 9-11

AUTOMOTIVE WASTE OIL QUANTITIES - 1978 (MM liters)

| | CRANKCASE OIL | HYDRAULIC OIL | TOTAL |
|---|---|---|---|
| Gasoline service stations[a] | 666.0 | 29.9 | 695.9 |
| Automobile repair shops[b] | 155.0 | 51.1 | 206.1 |
| New car and truck dealers[c] | 219.9 | 52.3 | 272.2 |
| Fleets[c,d] | 82.8 | 5.9 | 88.7 |
| Total | 1,123.7 | 139.2 | 1,262.9 |

[a] ERCO estimates, Table 9-9.

[b] ERCO estimates, Table 9-10.

[c] "Service Job Analysis," Service Station Management, 1975, 1978 and ERCO estimate.

[d] Fleets are defined as having 25 or more automobiles and a separate repair facility.

## 9.4 Number of Generators

Due to the decline in the number of service stations, the number of waste oil generators has decreased. Furthermore, the recent trend to self-service marketing has reduced the percentage of stations which perform service work. Table 9-12 displays the estimated number of generators as a percentage of the total number of service stations.

Table 9-13 illustrates the estimated number of independent repair shops that are generators of waste

TABLE 9-12

WASTE OIL GENERATORS - GASOLINE SERVICE STATIONS

| YEAR | TOTAL NUMBER OF SERVICE STATIONS | TOTAL NUMBER PERFORMING SERVICE WORK | TOTAL NUMBER OF GENERATORS | PERCENT OF TOTAL |
|---|---|---|---|---|
| 1978 | 171,000[a] | 131,700[c] | 118,530[e] | 77 |
| 1975 | 189,480[a] | 165,000[d] | 148,500[d] | 87 |
| 1972 | 226,459[b] | 194,000[d] | 174,600[e] | 86 |

[a] U.S. Dept. of Commerce, Franchising in the U.S. Economy, 1976-1978

[b] U.S. Bureau of the Census, Census of Retail Trade, 1972.

[c] ERCO estimates derived from "U.S. Service Stations by Types," 1978 National Petroleum News Factbook Issue, p. 106.

[d] "Service Job Analysis," Service Station Management, 1975, 1972.

[e] ERCO estimates based on assumption that 10% of stations generate less than 100 kilograms of waste oil per month.

## TABLE 9-13

## WASTE OIL GENERATORS - AUTO REPAIR SHOPS

| YEAR | TOTAL REPAIR SHOPS PERFORMING SERVICE WORK | TOTAL NUMBER OF GENERATORS |
|---|---|---|
| 1978 | 133,800[a] | 66,900[c] |
| 1975 | 121,000[b] | 60,500[c] |
| 1972 | 108,000[b] | 54,000[c] |

[a] ERCO estimate.

[b] "Service Job Analysis," Service Station Management, 1975, 1972.

[c] ERCO estimates based on assumption that 50% of the repair shops average less than 100 kilograms of waste oil per month.

crankcase oil. Approximately one-third of these generate hydraulic oil form transmission service as well. The estimates have been made by Service Station Management magazine based on their triennial survey, "Service Job Analysis." It is assumed that only 50 percent of these facilities generate over 100 kg/month. This is because many of them specialize in replacing auto glass, painting cars, auto body work and other areas, keeping down their waste generation.

In addition to automobile repair shops that generate waste crankcase oils, a small number of repair shops engage in transmission work only and thus are generators of hydraulic oils but not of crankcase oils. There are approximately 4,500 of these establishments currently operating in the United States based upon available census figures, updated from 1972.[15]

As mentioned above, new car and truck dealers and fleets of automobiles that have captive repair and service work done have significant amounts of both crankcase and hydraulic oil. The *Service Station Management* oil change survey estimates that there were 34,000 new car dealers and 35,000 fleets in 1975.[16]

## 9.5 Current Disposal for Waste Oils

### 9.5.1 Disposal Practices

The waste oils drained by gasoline service stations and auto repair shops are generally collected in underground storage tanks having a typical capacity of 1,890 liters or more (500 gallons). Occasionally, the waste oils are stored above-ground in 55-gallon drums or other containers. Little distinction is generally made between lubricating and hydraulic transmission oils. Their nature is similar enough that end uses are not affected by combining the two.

Roughly 80 to 90 percent of service stations and repair shops nationwide are turning their waste oil over to a waste oil collector. In urban areas, the percentage of firms using collection services appears to be 90 or more. In rural areas, collection is somewhat less commmon.[17] The collectors range from one-man, one-truck scavengers to waste oil collecting services that have established customers and routes.

In general, the collectors act as middle men, collecting oil for resale to other concerns that buy the waste oil for a variety of end uses (see below). Alternatively, the collector can be a part of a rerefining or processing firm that secures feedstocks of waste oil for their direct use. The major uses for waste automotive oils from service stations and repair shops are: (1) fuel, (2) road oil (including dust control), (3) rerefining, (4) asphalt extender and other construction uses, (5) other dust and weed control uses, and (6) input to miscellaneous manufacturing processes.

The amount of processing involved in each of the uses varies considerably. Waste oil to be used as road oils, as dust and weed control agents, and in construction uses generally does not require treatment. In fact, if the waste oil is allowed to settle, the heavier oily sludge can be used in these applications. For use as fuel, waste oil is commonly allowed to settle in order to remove major sediment or ash constituents. This practice helps prevent clogging of boiler equipment. The waste oil can undergo further processing such as centrifugation or filtering to remove sediment, but this is not done in most cases.

When oil is rerefined, it is processed such that virtually all trace metals and other contaminants are removed. After rerefining, the oil can be used as a base lubricating oil stock. The simpler processing steps necessary for use as fuel or road oils do not greatly reduce the levels of trace metals such as lead or zinc or other contaminants, although some sediment is removed.

Estimates of the percentages for several broad use categories are shown in Table 9-14 below.[18]

Recent estimates of rerefined oil quantities indicate that approximately 470 million liters of waste oil was rerefined in 1977.[19] Since total waste oil generation has not increased significantly, the percentage of oil going to

## TABLE 9-14

## WASTE OIL END USES[a]

| DISPOSAL METHOD | VOLUME (MM liters) | PERCENT |
|---|---|---|
| Burned as fuel | 1,820 | 43 |
| Road oiling | 760 | 18 |
| Rerefined | 340 | 8 |
| Others | 1,290 | 31 |
|  | 4,210 | 100 |

[a] U.S. Environmental Protection Agency, Waste Oil Study, April 1974.

rerefiners as shown in Table 9-14 may be an understatement of conditions as they exist today. Nevertheless, it is clear that rerefiners absorb only a small percentage of the waste oil that is currently collected from service stations, automobile repair shops, and other industrial sources. Since waste automotive oils are generally combined with other industrial waste oils at the reprocessor ore rerefiner, Table 9-14 will be assumed to apply to waste oil from service stations and automotive repair shops. Roughly speaking, then, fuel uses are four times as great and road oiling use is twice as large as the amount of waste automotive oil that is rerefined.

Adequate data do not exist to be able to estimate the share each of the six uses has in the disposal or reuse of waste oil.

### 9.5.2 Pricing of Waste Oil

Where service stations once had to pay to have their waste oil removed, waste oil collectors now generally pay the service stations for the oil they collect.[20] The price paid is based upon a number of factors:

1. End use for the oil.

2. Competitive pressures and demand for waste oil in a region.

3. The quantity collected at one time.

4. The quality of the waste oil.

The end use of the oil plays a large part in the price paid for the waste oil. Where the waste oil will be used for fuel uses or road oiling, prices are generally higher. The price paid to the station owner may be up to 25 cents per gallon. If the oil is to be taken to a rerefiner, the station owner is likely to receive from 0 to 10 cents per gallon. The production costs necessary in rerefining and the relative prices of fuel oil and lubricating oil put rerefiners at a competitive disadvantage vis-a-vis firms that process waste oils for fuels or road oiling. This competitive disadvantage has not changed despite changes in fuel prices. Thus, rerefiners generally pay less to collectors for their waste oil than do firms that make use of the waste oil in other ways.

Competitive pressures also affect the price paid for waste oil. The high demand for waste oil in urban, industrialized areas can force collectors to pay increased prices to service stations or repair shops for their oil. Conversely, in rural areas, stations may not be paid at all by the waste oil collector.

Quantity also affects the price paid for waste oil; a collector's operating costs increase with the number of stops necessary to fill the collector's truck. Large oil quantities are sought after and earn a higher price. However, competition often forces a collector to pick up smaller quantities rather than risk the chance that the oil will be pirated by others.

Finally, the price collectors receive for the oil they collect varies according to the quality of the waste oil. Oil contaminated by water or excessive sediment is less valuable than noncontaminated oil.

## 9.6 RCRA Specified Disposal

The RCRA regulations will not appreciably alter the current practices of service stations and repair shops with regard to disposal of waste oils. They are more likely to impinge upon the collectors and users of waste oil. These changes are discussed briefly below for Options A and B.

In keeping with the RCRA "cradle to grave" control philosophy, waste oil must be collected, transported, and disposed of in a fashion consistent with hazardous waste management regulations. The current collection practices of service stations and repair shops (collection in tanks or drums for pickup by collectors) appear to be adequate for compliance with these regulations. Also, the transport of waste oil should continue to be done by an established network of waste oil collectors. The principal question is the effect of RCRA (Option A and B) on the end uses of waste oil. A reduction in the end use markets (thus a drop in demand) would affect the price paid to service station and repair shop owners for their waste oil.

RCRA Option A (Subsection 250.56, "Commercial Products," March 1978 draft) requires that the commercial use of waste oil not cause greater environmental degradation than the use of virgin oil. A similar stipulation is made in RCRA Option B (Section 250.45-7, September 1978 draft) regulations, with the additional requirement made that waste oil which is to be used as fuel must contain less than 8 ppm (parts per million) lead. In general only rerefined waste oil meets these standards. Under these standards road oiling and dust control uses for unprocessed waste oils would not be allowed. However, uses for waste oil other than as rerefining feedstocks will be allowed by permitted facilities. The major use to be permitted is likely to be use as a fuel oil.[22]

Thus, only two principal end markets for waste oil will remain after the implementation of RCRA: (1) use as a fuel (at lower than current levels) at permitted facilities and (2) use as rerefining feedstock. The costs involved in rerefining should render the resulting oil too costly for use as a road oil or weed control agent. A determination of the likely size of the end use markets was beyond the scope of this study. However, it appears likely that there will be at least a short-term drop in waste oil demand. In order to consider the economic impacts of a fall in demand for waste oil, several assumptions were made concerning waste oil prices. The assumptions are described in the next section.

## 9.7 RCRA Compliance Costs

### 9.7.1 Technical Costs - Prices for Waste Oil

The facilities are already available for the collection and storage (temporary) of waste oils at service stations and repair shops. No incremental RCRA costs were allotted for purchases of storage tanks or drums for waste oil collection. The only "technical" costs incurred will be due to changes in the price paid for waste oil collection.

As mentioned above, most stations and shops are currently being paid anywhere from a few cents to $0.25 per gallon for waste oil collection. Most stations appeared to receive from $0.05 to $0.15 per gallon. With the likely decline in demand for waste oil, the price paid will fall. For the economic analysis, it will be assumed that the service station or repair shop owner is currently being paid $0.10 per gallon. Under RCRA it is assumed the price falls such that he must pay $0.10 per gallon for pickup because of the decrease in end use markets for the oil. Thus, a $0.20 per gallon ($0.052 per liter) price swing is assumed. This price swing will be used for both model and worst-case firms in these industries. (The worst-case firm is defined principally in terms of current earnings rather than complianc costs. This definition was judged to be most realistic and to best cover the range of industry impacts.) The assumption about the price swing is intended as a liberal judgment of actual impacts. That is, a relatively large price swing was used in order to not underestimate impacts.

### 9.7.2 Administrative Costs - Option A

The administrative costs for gasoline service stations and automotive repair shops are based on a preliminary draft report by another EPA contractor, Arthur D. Little Inc.[23] However, unlike the administrative costs used in the other chapters, the ADL figures have been revised downward to reflect the lower price of time for service station and repair shop employees and owners. The costs for these industries are shown in Table 9-15.

It has been assumed that the station or repair shop owner or a mechanic would perform the technical or supervisory compliance. The value of a mechanic's time is used as the hourly basis for cost estimates. This time will be charged at the rate of $18/hr. The cost may be interpreted as the opportunity cost of the owner's or mechanic's time. No non-labor expenditures, such as purchases of typewriters, have been assumed.

Additional changes in the ADL estimates were made due to the relative simplicity of the anticipated compliance activities. Much of the mechanism for compliance is in place for this industry. In particular, there need be little change in the methods of waste oil collection or storage. The system design costs for compliance have been reduced accordingly. Other tasks, including the documentation of waste inventory, maintenance of the Section 3001 list, and identification of a transporter have been reduced or eliminated.

## TABLE 9-15

## ADMINISTRATIVE COSTS FOR GASOLINE SERVICE STATIONS AND AUTOMOTIVE REPAIR SHOPS[a]

| | OWNER, MECHANIC ($18/hr) | OPTION A COST ($) | OPTION B COST ($) |
|---|---|---|---|
| Section 3001 | | | |
| 1. Documentation of waste inventory | 1 | 18 | - |
| 2. Supervision and determination of applicability of Section 3001 | 2 | 36 | 36 |
| Section 3002 (Generators) | | | |
| 1. ID code application | 1 | 18 | 18 |
| 2. Quarterly and annual reports | 4 | 72 | - |
| 3. Storage of liability contracts | - | NA[b] | 20/yr |
| 4. Manifest handling ($3/manifest x 1 manifest/month) | - | 36/yr | - |
| 5. System design for labeling, manifesting, reporting, and identification of transporter | 4 | 72 | - |
| 6. Ongoing supervision | 4 | 72 | - |
| Total costs (first year) | | 324 | 74 |
| Recurring annual costs[c] | | 180/yr | 20/yr |

[a] ERCO estimates.

[b] Not applicable.

[c] Recurring costs are denoted as $/yr entries.

### 9.7.3 Administrative Costs - Option B

Administrative requirements were reduced under Option B. The only necessary tasks are ID code application and storage of liability contracts (entered into with the waste oil transporter), and the initial determination of the applicability of Section 3001. The costs under Option B are also summarized in Table 9-15.

## NOTES TO CHAPTER 9

1. Based upon ERCO discussions with industry personnel and ERCO estimates of crankcase and hydraulic oil quantities.

2. ESSO analysis reported in Waste Oil Recycling and Disposal, Norman J. Weinstein, Recon Systems Inc. August 1974.

3. "Waste Oil Lubricating Oil Research: Characterization of Base Stocks from Used Lubricating Oils," Part 1, M.L. Whisman et al., Bartlesville Energy Research Center, 1975.

4. "Used Oil: Collection, Recycling, and Disposal," William A. Irwin, Technology Review, August/September 1978, p. 55.

5. Based on personal communication of Steve Fischer of ERCO and Mr. Tom Sheehan of Lubrizol Inc., November 1978.

6. National Institute for Occupational Safety and Health, Registry of Toxic Effects of Chemical Substances, 1976.

7. According to the 1975 Service Station Management magazine, "Service Job Analysis."

8. Sixty-two percent of gasoline stations with service bays do no transmission work at all based on average waste oil generation figures.

9. Waste Oil Recycling and Disposal, Norman J. Weinstein, Recon Systems, Inc., and Response Analysis Corporation, 1974.

10. Service Station Management, "Service Job Analysis," 1975, 1972, 1969, obtained by telephone interview.

11. "Can Stations Plug the Leaks?," Merrill O'Brien, National Petroleum News, April 1978, p. 50.

12. ERCO estimates.

13. The number of automobiles is taken from 1978 National Petroleum News Factbook, p. 103, and Federal Highway Administration estimates.

14. A fleet is an establishment with 25 or more vehicles that does its own repair work.

15. U.S. Bureau of the Census, Census of Selected Service Industries, 1972. The Census reported 2,449 establishments with payroll that were operating primarily as transmission repair shops. Establishments without payroll (i.e., those firms operated as a single proprietorship or partnership without hired help) were not reported. In order to include these firms, the number of firms with payroll was multiplied by 1.5. This calculation was based on the ratio of business with to businesses without payroll in the general automotive repair shop category. The estimate was then scaled upward to 1978 based upon the increase in the number of cars on the road.

16. "Service Job Analysis," Service Station Management, 1975.

17. Based upon ERCO contacts with urban area collectors and estimate above.

18. U.S. Environmental Protection Agency, Waste Oil Study, Report to the Congress, April 1974, p. 1.

19. Management of Environmental Risk: A Limited Integrated Assessment of the Waste oil Rerefining Industry, Teknekron, Inc., Resource Management Division, 1978, p. xxi.

20. Teknekron, Inc., A Technical and Economic Study of Waste Oil Recovery, Part II, 1973, p. 21.

21. Based upon telephone conversations with waste oil collectors, service stations, automotive repair shops, and rerefiners.

22. The presumption that some facilities would be permitted to burn waste oil is based on personal communication between John Eyraud and Steve Fischer of ERCO and personnel in the EPA Office of Solid Waste, October 26, 1978.

23. Arthur D. Little, Inc., Preliminary Integrated Economic Impact Assessment of Hazardous Waste Management Regulations, October 1978.

# CHAPTER TEN

# ECONOMIC IMPACT ASSESSMENT FOR GASOLINE SERVICE STATIONS AND AUTOMOTIVE REPAIR SHOPS

This chapter consists of three sections. First, the administrative and technical disposal costs resulting from RCRA regulations (which were developed in Chapter Nine) are analyzed with respect to the model plants developed in Chapter Eight. In this analysis, it is assumed that prices (and sales) remain constant. In this way the incremental cost of compliance with regulations can be isolated. A second section describes the impacts at the aggregate national level. A third section then analyzes the actual impact on establishments including consideration of price increases to pass through increased costs.

## 10.1 Model Firm Impacts

### 10.1.1 Gasoline Service Stations

Tables 10-1 and 10-2 display the effects of RCRA Options A and B upon gasoline service stations' net income. The analysis covers the effects upon a model firm and a worst-case firm as described in Section 8.1.4.

As can be seen from Table 10-1, Option A disposal costs, both technical and administrative, amount to approximately $500 for both the model and worst-case firm. This cost should impose a significant burden only on the already

### TABLE 10-1

### IMPACTS ON GASOLINE SERVICE STATION MODEL FIRMS (OPTION A)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales | 344,900 | 246,700 |
| Cost of operations | 327,400 | 243,200 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 216 | 216 |
| Administrative costs[b] | 324 | 324 |
| Pretax net income and compensation of officers | 16,960 | 2,960 |
| Pretax net income and compensation of officers (before RCRA) | 17,500 | 3,500 |
| Decline in pretax net income | 3% | 15% |

[a] ERCO estimates.

[b] First year administrative costs are shown, rounded to the nearest $100. Recurring annual costs are $180.

### TABLE 10-2

### IMPACTS ON GASOLINE SERVICE STATION MODEL FIRMS (OPTION B)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales | 344,900 | 246,700 |
| Cost of operations | 327,400 | 243,200 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 216 | 216 |
| Administrative costs[b] | 74 | 74 |
| Pretax net income and compensation of officers | 17,210 | 3,210 |
| Pretax net income and compensation of officers (before RCRA) | 17,500 | 3,500 |
| Decline in pretax net income | 2% | 8% |

[a] ERCO estimates.

[b] First year administrative costs are given. Recurring annual costs are $20.

marginal worst-case gasoline service station. The model firm would experience a 3 percent drop in income while the worst-case firm would experience a 14 percent decrease in the first year. These impacts will diminish by 30 percent after the first year, but will still remain a significant burden for worst-case firms in remaining years. These impacts are more significant when it is remembered that the net income figures represent the earnings of the owner and are not merely a corporate profit.

Option B impacts (Table 10-2) are approximately 40 percent less than those for Option A. The decrease in total compliance costs is due to the reduced reporting requirements under Option B. The total costs for both firms are reduced to $300. The Option B compliance costs represent less than 2 percent of the model firm's net income. The worst-case firm will still suffer a significant decrease in net income, with pretax net income expected to fall 9 percent over pre-RCRA levels.

### 10.1.2 Automotive Repair Shops

Tables 10-3 and 10-4 show that the impacts of Options A and B regulations are slightly more pronounced on the model automotive repair shop than on the model gasoline service station. Under Option A, the total increased costs for compliance are again approximately $500. However, because of lower pretax net income levels for automotive repair shops, the model firm experienced a 5 percent decrease in pretax income. This contrasts to the 3 percent decrease in net income for the model firm gasoline station. The worst-case automotive repair shop suffers a 7 percent drop in net income.

## TABLE 10-3
## IMPACTS ON AUTOMOTIVE REPAIR SHOP MODEL FIRMS (OPTION A)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| (With regulation) | | |
| Sales | 80,000 | 40,000 |
| Cost of operations and expenses | 69,000 | 32,500 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 162 | 162 |
| Administrative costs[b] | 324 | 324 |
| Pretax net income and compensation of officers | 10,514 | 7,014 |
| Pretax net income and compensation of officers (before RCRA) | 11,500 | 7,500 |
| Decline in pretax net income | 9% | 6% |

[a] ERCO estimates.

[b] First year administrative costs are shown. Recurring annual costs are $180.

## TABLE 10-4

## IMPACTS ON AUTOMOTIVE REPAIR SHOP MODEL FIRMS (OPTION B)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| (With regulation) | | |
| Sales | 80,000 | 40,000 |
| Cost of operations and expenses | 69,000 | 32,500 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 162 | 162 |
| Administrative costs[b] | 74 | 74 |
| Pretax net income and compensation of officers | 10,764 | 7,264 |
| Pretax net income and compensation of officers (before RCRA) | 11,000 | 7,500 |
| Decline in pretax net-income | 2% | 3% |

[a] ERCO estimates.

[b] First year administrative costs are shown. Recurring annual costs are $20.

Option B impacts (Table 10-4) are reduced compared to Option A in a fashion similar to the case of gasoline service stations. The incremental compliance costs are reduced to approximately $300 per firm, which represents decreases in pretax net income of 3 and 4 percent for the model and worst-case firms, respectively. Moderate in size, these impacts would not appear to seriously affect the operations of automotive repair shops.

## 10.2 Aggregate National Impacts

Estimates of the total aggregate costs of compliance for the gasoline service stations and automotive repair shops are displayed in Tables 10-5 and 10-6 for both regulatory options. The aggregate costs were calculated by assuming that the model firm compliance costs were representative of the average for the generators in the industry. Technical disposal costs and administrative costs were taken from Section 9.6. The total sales figure of the generators in both industries was estimated by assuming an average sales figure per generator and multiplying it by the number of generators. In the case of gasoline service stations, an average sales figure of $269,900 was used.[1] Automotive repair shop average sales were taken from the model firm sales figure ($80,000).

In no case are aggregate impacts greater than 0.6 percent of total sales of the generators. Aggregate compliance costs for gasoline service stations are estimated to be 70.1 million dollars for Option A and 37.1 million dollars for Option B. As a percentage of total generator sales, the aggregate costs are less than 0.2 and 0.1 percent for Options A and B respectively. Automotive repair shop

## TABLE 10-5

## AGGREGATE COST OF COMPLIANCE FOR THE GASOLINE SERVICE STATION INDUSTRY ($MM)

| | OPTION A | OPTION B |
|---|---|---|
| Number of generators[a] | 118,530 | 118,530 |
| Costs | | |
| Technical | 25.6 | 25.6 |
| Administrative[b] | 38.4 | 8.8 |
| Total | 64.0 | 34.4 |
| 1977 sales value[c] | 40,319.0 | 40,319.0 |
| Costs as % of production value | 0.2% | <0.1% |

[a] Estimate made for 1978.

[b] First year administrative costs are shown. Recurring administrative costs are $21.3 MM for Option A and $2.3 MM for Option B. This reduces total cost by almost 27 percent for Option A and almost 20 percent for Option B in succeeding years.

[c] Includes production value for generators only.

## TABLE 10-6

## AGGREGATE COST OF COMPLIANCE FOR THE AUTOMOTIVE REPAIR SHOP INDUSTRY ($MM)

| | OPTION A | OPTION B |
|---|---|---|
| Number of generators | 66,900 | 66,900 |
| Costs | | |
| Technical | 10.8 | 10.8 |
| Administrative[a] | 21.7 | 5.0 |
| Total | 32.5 | 15.8 |
| 1977 sales value[b] | 10,352.0 | 10,352.0 |
| Costs as % of production value | 0.3% | 0.2% |

[a] First year administrative costs are shown. Recurring administrative costs are $12.0 MM for Option A and $1.3 MM for Option B. This reduces total cost by almost 30 percent for Option A and 25 percent for Option B in succeeding years.

[b] Includes production value for generators only.

aggregate costs are estimated to be 66.6 million and 32.0 million dollars for Options A and B. These costs translate into only 0.6 and 0.3 percent of total sales of generators in 1977.

It should be noted that the technical compliance cost estimates are dependent on the speculative assumptions about the impact on the price of waste oil disposal. The possible range for compliance costs appear to be $10 to $50 million depending on the actual price swing. Approximately half of the technical compliance costs, as presented here, are due to the loss of current revenues from waste oil sales (2.6 cents/liter in revenue) was assumed. The loss of revenue alone would involve a total cost to these industries of over $10 million.

## 10.3 Industry Impacts

Model plant impacts of both Option A and Option B regulations should also be mitigated by price increases as well as the unpaid overtime efforts of the firm owner. Discussions with industry personnel indicate that an increase in the technical cost of disposal is likely to be passed along in the price charged to consumers for motor oil and transmission fluid.[2] This same increase in price can be expected to be observed by repair shop owners. The cost of oil to consumers is a very small part of the total amount of services purchased from service stations or repair shops. Therefore, demand for motor oil and transmission fluid is assumed to be inelastic over the 5 cents/quart range required to absorb a change in disposal costs. Administrative costs may also be added to the purchase price for oil or other products without inducing a significant drop in the quantity of oil sold or in the amount of other services provided.

In the case of Option A where administrative costs are much higher, competition is likely to prevent a full pass-through of costs. Much of the remaining burden may be absorbed. It is likely that if administrative cost increases severely burden either a gasoline service station or an automotive repair shop, the owner will absorb the cost of his additional labor by performing administrative functions himself in unpaid overtime. By performing administrative tasks himself, the owner will lose his free time but maintain the company's net income which ultimately (in a proprietorship) constitutes his own income.

Because of the mitigating factors noted above, it is likely that few stations will close for reasons directly attributable to either option of the regulations. Of course, already marginal firms may close sooner because of the regulation. The increased cost of providing oil changes to customers may also provide a small inducement for service stations to eliminate their service bays and convert to self-service.

A further effect of RCRA that may not show up in terms of economic impact should also be noted. If in fact service stations end up paying to have their waste oil removed, many service station and garage owners will be unwilling to provide a place for waste oil disposal by individuals who have changed their own oil.[3] In light of the large volume of waste oil from do-it-yourselfers, the reluctance of service station and garage owners to accept other waste oil may necessitate the establishment of locally funded collection facilities for waste oil, or an acceptance of the haphazard disposal practices of individuals.

## NOTES TO CHAPTER TEN

1. *1978 National Petroleum News Factbook* Issue, Business at Service Stations, p. 103.

2. Personal communication of Steve Fischer, ERCO, with members of Edwin K. Williams and Co., Santa Barbara, California, November 16, 1978.

3. Based upon telephone conversations of Steve Fischer, ERCO, with gasoline station proprietors.

# PART IV

## DRUM RECONDITIONERS

Preceding page blank

# CHAPTER ELEVEN

# CHARACTERIZATION OF THE DRUM RECONDITIONING INDUSTRY

The basic data on the drum reconditioning industry is presented below in four sections. The first covers the basic data on industry size and industry functions. The second section provides an overview of industry structure and performance. The third covers available financial data. A final section describes the model plants to be used in the analysis.

## 11.1 Size and Scope of the Industry

### 11.1.1 Industry Definition

The drum reconditioning industry is a small service industry, subsumed in SIC 5085, which cleans steel drums for reuse. Reconditioning firms accept empty drums from a wide number of sources for processing. The drums are then cleaned, reshaped, painted, lined (if desired) and often resold as substitutes for new drums. Most of the drums handled are 55-gallon drums although some firms handle 30-gallon drums. The industry is a resource-conserving industry because the steel drum is a reusable container, which typically can be reconditioned eight times. The industry also provides an implicit disposal service to a variety of companies for reconditioning drums that contain residual amounts of oils and chemicals. This disposal service thus reduces the likelihood of haphazard disposal of used drums. Though a resource conservor, the drum

**Preceding page blank**

reconditioning industry will be examined because in the process of cleaning drums, a quantity of hazardous waste is generated.

The reconditioning of drums can be performed either as a service to the drum owner or as an outright purchase and resale of the drum. In the first case, the reconditioner picks up the drums from the owner and returns the reconditioned drums. The owner of the drums pays a fee for cleaning and reconditioning, which will usually include a charge for the expense of pick-up and delivery. The charge for this service varies from $3.50 to $5 per drum. The quality of the reconditioning job desired by the customer is one determinant of price. Most reconditioning services are equipped to coat or line the inside of the drums with a variety of materials. Coatings are required in the shipment of many chemicals to prevent a reaction with the steel drum. A single coat of liner adds $1.50 to $2.50 to the cost of the drum.

A slightly more common practice is for the reconditioner to purchase the drum outright. Reconditioning firms will pay from $2 to $4 per drum depending on (1) the transportation costs involved, (2) the expected difficulty of clean-up, and (3) the number of drums to be purchased.[1] The drums are then processed and resold to industrial accounts.

### 11.1.2 Industry Sales

Industry sales figures are no longer published for the reconditioning industry by the Census Bureau. Estimates of sales volume vary from $500 to $900 million. The annual volume of reconditioning business has been estimated at from

45 to 50 million drums.[2] However, in recent years, the drum reconditioning industry has grown. The extent of the growth can not be accurately determined. Volume for 1977 could be 50 to 70 million drums.[3]

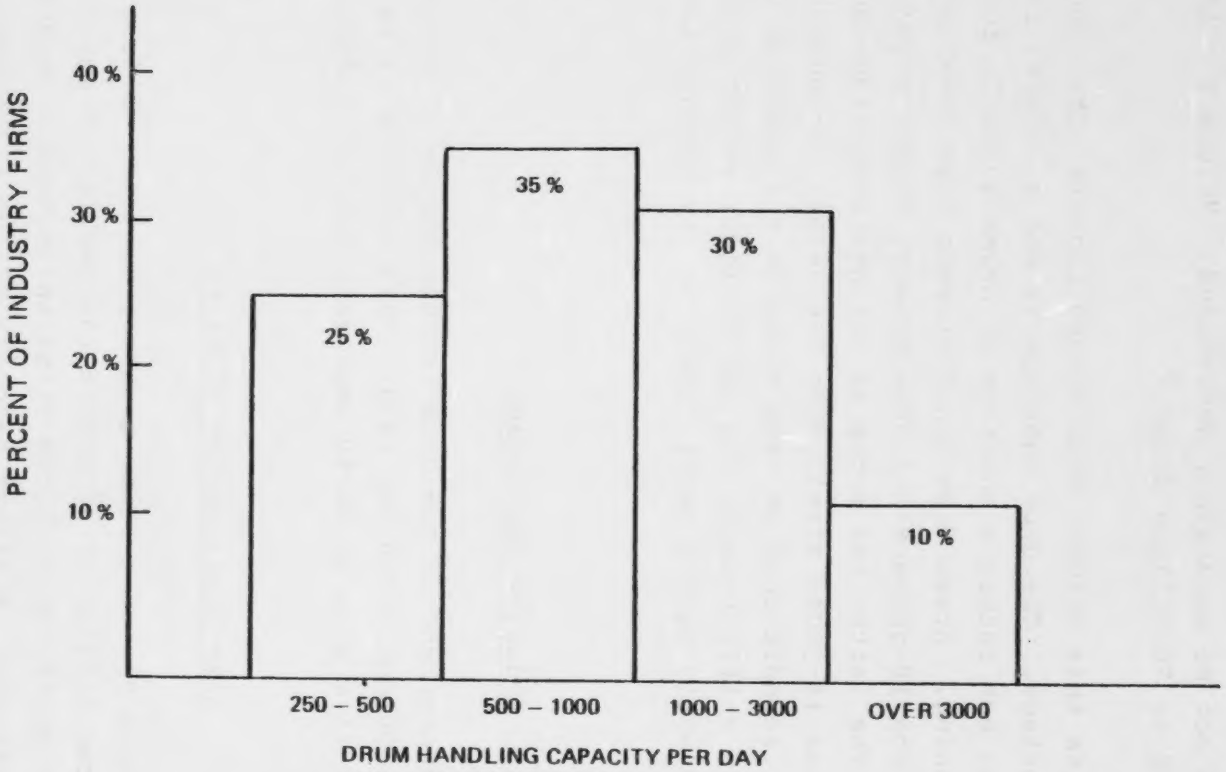
Despite this volume, drum reconditioners often speak of a drum shortage. The drum shortage is not a literal lack of containers, but rather a shortage of drums suitable for reconditioning. Steel drum manufacturers have been moving away from the 18-gauge steel drum product toward a 20/18-gauge product. The latter has a top of thinner steel (20-gauge is lighter than 18-gauge steel) with the normal 18-gauge body and cannot be reconditioned as many times as the standard drum. Large-scale shifts towards the use of light-weight steel containers would have a major impact on the reconditioning industry.

### 11.1.3 Industry Employment

The employment in the drum reconditioning is estimated at between 6,000 and 8,000 for 1978. This estimate is based on an average firm size of 30-40 employees for 190 industry firms.

### 11.1.4 Size Distribution of Firms

The drum reconditioning industry consists of from 180 to 190 firms ranging in size from the smallest firms which handle 200 drums/day to large firms which handle several thousand per day. A slight majority of the firms handle less than 1,000 drums/day. The size distribution of industry firms is shown in Figure 11-1. These enterprises are typically family-owned. In the 1970's the industry has



( Source: ERCO estimates )

Figure 11-1. Estimated size distribution of firms in the drum reconditioning industry.

begun to evolve toward a larger corporate scale of organizations.[4] The move has occurred due to the greater capital requirements needed for new enterprises. The most efficient scale of operation appears to be over 2,000 drums/day. Also, small firms have greater operating problems, including the need to upgrade facilities to meet air and sewer discharge regulations.

### 11.1.5 Regional Distribution of Firms

Most drum reconditioning firms are located in large urban areas or near industrial complexes in order to effectively serve their major sales markets. While both the petroleum and chemical industries have production facilities concentrated in the Gulf area of Texas and Louisiana, this area does not have the largest concentration of reconditioning firms. The products of these firms are generally shipped in bulk (tankers, pipelines, tank cars) to distribution points nearer sales markets. At these distribution points the products can be drummed for final shipment to customers. The heaviest concentrations of firms exist in the Northeast, Ohio, California, and Illinois. Relatively few firms are located in rural areas, although some rural cooperatives have established cooperages (drum-making or reconditioning establishments) for handling pesticide drums.[5]

The relatively small number of reconditioning firms means that individual firms can be expected to have some influence over the market in its immediate vicinity. Competition is greatest in the large metropolitan or industrial areas where there tend to be several firms operating. However, in less concentrated markets there may be only one to three active firms. The number of firms in an immediate area is significant due to the importance of transportation costs to the total costs of operation. A local firm will tend to have some leeway in price setting as long as the price does not rise to the point at which an outside firm could make a profit while undercutting the local firm's price. The issue of local market power will be discussed further below in Section 11.2.

## 11.2 Industy and Market Analysis

The principal markets for reconditioned drums are displayed in Table 11-1. Three industries dominate the use of reconditioned drums. The largest user of reconditioned drums is the petroleum industry. Petroleum shipments utilize 35 percent of all reconditioned drums. Firms in this industry usually prefer to retain ownership of the drums and pay the reconditioning service charge. The second largest customer is the chemical industry. Chemical firms normally do not retain ownership of the drum, preferring

TABLE 11-1

PRINCIPAL MARKETS FOR RECONDITIONED DRUMS[a]

| INDUSTRY | PERCENT OF MARKET |
|---|---|
| Petroleum | 35 |
| Chemical | 30 |
| Paint, varnish | 25 |
| All other | 10 |

[a] ERCO estimates.

to sell the drum with their.chemical shipments. The chemical industry is the largest purchaser of drums with linings. The third largest user of reconditioned drums is the paint and varnish industry. As noted in Table 11-1, this end market is estimated to be only slightly smaller than that of chemicals. Other industrial users include manufacturers of cleaning compounds, janitorial supplies, foodstuffs, and some agricultural products.

The separate industry markets are also different with regard to the types of drums sold. The "bung" type or tight-head drum has two plugs (a 3/4-inch plug and a 2-inch plug) in the top of the drum. The top itself is permanently attached to the drum. This drum type is used most conveniently for packaging of freely flowing liquids. The oil industry uses a large number of these drums for lubricating oils. Liquid chemicals are also likely to be shipped in "bung" type drums.

Open-head drums have a top which is secured with a metal ring around the drum perimeter. For pouring, the drum top is completely removed. The open-head drum is used for paints and more viscous materials such as adhesives.

The market for reconditioned drums, while derived largely from major industries, is not restricted to large companies. The number of industrial accounts per firm appears to vary from a few (even one) to several hundred. The larger firms tend to service the major oil and chemical firms. However, some small firms may hold only one account serving a large refinery or chemical complex. Large firms also may retain a number of medium and small accounts. Many firms provide the majority of service to their local areas and therefore also sell to small-volume purchasers.

### 11.2.1 Industry Structure

The nature of competition in the drum reconditioning industry is largely a function of two factors: (1) the degree of substitutibility between new and reconditioned drums and (2) the importance of economies of scale in operation. The first factor defines the niche for the reconditioning industry in the broader steel container market. The second concerns the size of individual firms relative to the entire local market for drums. Each factor will be discussed below.

The substitutes for the 55-gallon reconditioned steel drum are nonsteel containers, bulk containers, and new steel drums. Neither of the first two factors has a significant influence on drum markets. Plastic or fiber containers are currently more expensive than steel drums and are not usually seen as effective substitutes. Bulk containers (containers of 500 to several thousand gallons) have been used increasingly in pesticide distribution, but are not common in general industrial use. Thus only new steel drums are an effective substitute product.

Reconditioned drums can compete effectively with new drums because the reconditioning operation is less expensive. Average prices on the East Coast for reconditioned and new drums are shown below in Table 11-2. West Coast prices are from $1 to $2 higher per drum because the present shortage of drums is more serious in this region.

Table 11-2 clearly shows that reconditioned drums have a price advantage over new drums. Industry sources state that the gap between new and reconditioned drum prices has closed slightly in recent years due to the cost increases for reconditioners of materials and for a variety of pollution

TABLE 11-2

NEW AND RECONDITIONED DRUM PRICES[a]

| DRUM TYPE | PRICE |
|---|---|
| 18 gauge, new | $15.50 |
| 20/18 gauge, new | $14.00 |
| 20 gauge, new | $12.50 |
| 18 gauge, reconditioned | $9.50 |

[a] Figures were obtained through discussion with industry personnel.

abatement measures. However, the change does not appear to have caused a significant movement away from reconditioning. Furthermore, the remaining price differential of $4 to $6 indicates that the industry has a substantial cushion should reconditioning prices rise significantly in the future. The price elasticity of demand for reconditioned drums is estimated to be low (0.1 to 0.5) under existing market conditions.[7] This means that if prices increase by 1 percent, demand for drums will decline only 0.1 to 0.5 percent.

Despite the clear price advantage for reconditioned drums, the industry has been affected by the increasing use of lighter steel drums. The standard 55-gallon drum is made entirely of 18-gauge steel. The 20/18 drum has a 20-gauge steel body and a 18-gauge steel top and bottom. This drum is a popular item for purchasers of new drums because it is cheaper and lighter. The standard drum weighs 46 lb, but the 20/18 gauge weighs 38 lb due to the thinner top. A still lighter drum made of 20-gauge steel is also being sold. The 20-gauge drum weighs 28 lb.

The lighter drums are a problem for industry markets because they are less suitable for reconditioning. The 20/18-gauge drum can be reconditioned only three times, compared to eight for the standard drums.[8] The 20-gauge drum can be used from 1 to 3 times. To the extent that purchasers of new drums choose the lighter types, fewer drums remain available for reconditioning. The market shares for these drums reduce the market share for 18-gauge drums, and the rate at which the 18-gauge population is replenished is reduced. The market shares for the various drums are shown below in Table 11-3.

TABLE 11-3

MARKET SHARES FOR NEW DRUMS[a]

| DRUM TYPE | PERCENT OF NEW DRUM MARKET |
|---|---|
| 18 gauge | 40 |
| 20/18 gauge | 50 |
| 20 gauge | 4 |
| Other (16 and 24 gauge) | 6 |

[a] ERCO estimates and U.S. Dept. of Commerce, Census of Manufacturing, Series M-34K, 1978.

Use of the lighter drums has been particularly high in the chemical industry, which is also one of the largest markets for reconditioned drums. The chemical industry, as a general rule, sells the steel container along with the chemical product in its transactions. Since the firm making the shipment does not plan to reuse the drum, the 20/18-gauge drum or the 20-gauge drum is likely to be purchased. The increasing popularity of the lighter drums could cause a decline in the demand for reconditioning. The long-range implications of throw-away containers are not immediately serious. The industry's largest market, the oil industry, has moved only slightly toward lighter drums. Also, the increased problem of disposal for lighter drums will impinge upon further increases in market shares. The problem is counterbalanced by the generally increasing interest in reconditioning. Concern with solid waste disposal and environmental problems appear to have been at least partly responsible for the increased sales.

The level of competition in the drum reconditioning industry is partially determined by the degree of industry concentration and by the related issue of restrictions on the entry of new firms into the market. Industry concentration ratios are low, which often indicates a highly competitive industry. While no complete figures are available, it is a simple matter to compare the sales volume of the largest firms with the total industry volume. Estimating that the average sales volume for each of the four largest firms is 5,000 drums per day, the four-firm concentration ratio is 8 percent. The eight-firm concentration ratio is estimated to be approximately 13 percent.[10] These ratios indicate that major firms do not appear to dominate the national market.

A more telling set of statistics for this industry are the concentration ratios of local or regional markets. Only rough estimates of local concentration ratios can be made due to the problem of defining local markets and due to the lack of information about individual firm sales.

However, local concentration ratios appear to be high. The number of reconditioners in major metropolitan areas varies from 5 to 10. In small-sized industrial areas there may be only one to three firms which can provide reconditioning services.[11] The transportation cost portion of operating costs is significant and most firms rarely go beyond 200 miles.[12] Therefore, local firms can slightly undercut competitors from other regions. If there is only one local firm, it will then be able to collect slightly above average profits. In practice, there appear to be local monopolies in only a few isolated markets and in the West where travel distances prohibit some competition. In the East there is much overlapping of the operating circles of firms.

There is an implicit barrier to entry in that a single firm may have sufficient capacity to recondition a large percentage of the drums used in a given region. New entrants are discouraged by the difficulty in establishing an industrial clientele. This barrier to entry, however, is not currently very significant because increasing demand for reconditioned drums has allowed some room for expansion and new entry.

### 11.2.2 Industry Conduct and Performance

The recent trends in the industry have been dominated by the growth of demand for reconditioning and a resulting expansion move. With growing demand, reconditioners have been able to operate at close to capacity. Several firms reported that they were operating at virtually 100 percent of capacity. Additional drums could be handled only by employing an additional shift of workers. Two firms did report operations at only 60 to 70 percent capacity, but higher rates were more common. High utilization rates tend to reduce price competition because firms have less incentive to develop new markets. Contacts with industry personnel indicated a general ability to earn $0.50 to $0.70 per drum, i.e., "good" profits and solid market outlooks.

The good profit picture has encouraged the consolidation movement taking place in the industry. Several large firms have acquired older facilities, as they became available, to form chains of reconditioners. Existing firms have also expanded and modernized their facilities to accommodate a greater volume of business. The capital investment requirements for meeting environmental regulations has also spurred the shift away from the traditional family-owned and -operated plants.

Industry consolidation has not led to significant domination of local markets by individual firms. Those firms which have acquired other facilities have typically been buying property in other states. For example, one large chain of reconditioners, Great Lakes Container Corporation, has operations spread over the East and Midwest. These operations do not have overlapping spheres of coverage which would allow them dominance in a regional market.

Pricing policies follow the standard mark-up technique of pricing. The strength of demand has also encouraged price increases to recover cost increases. Industry sources have reported a steady rate of increases in the 1970's in reconditioned drum prices due to increases in fuel, chemical and labor costs. The higher cost of building facilities has presumably required larger capital charges on the price of the service.

## 11.3 Financial Characterization

No published information is available on the historical profits or financial status of industry firms. Discussions with industry personnel reveal that pre-tax net income of 10 percent of sales is generally being achieved in 1978. The industry sales growth has been quite strong of late, and much expansion is taking place.

## 11.4 Model Plant Description

A hypothetical model plant will be described in this section and will form the basis for much of the economic impact analysis. A worst-case plant will also be defined. The latter will be used to measure the likelihood of extreme impacts (i.e., plant shutdown) due to regulation.

The model plant is assumed to handle 1,000 drums per day and operate 250 days out of the year. The 1,000-drum volume is slightly above the industry median. The relatively large size is useful for analysis because it can be assumed that such a plant would generate each of the major waste streams of interest. A desription of the major process wastes and quantities is provided in the next chapter.

Gross revenues are calculated on the premise that all of the drums are handled as a service to their owners. That is, none of the drums are being bought outright and resold. Firms which buy most of their drums outright for resale generally earn higher profits. However, in order not to understate impacts the former assumption will be used. Prices for the reconditioning service range from $3.50 to $5.00. An average price of $4.50 will be used here.

Profit margins are normally defined in terms of cents per drum handled. Profit margins range from $0.40 to $0.70 per drum. The value of $0.50 per drum will be used here because it appears to be closest to an average figure based on discussions with industry. The assumption will be modified for the worst-case firm.

Current solid waste disposal costs vary widely among firms. Most firms reported disposal costs of between $3.50 and $9.00 per drum of waste. A few firms operating in states with stringent disposal regulations have already incurred costs similar to those which the industry will face under RCRA. The conservative assumption will be made that the model firm is now paying $4/drum for disposal ($13.10/MT at a specific gravity of 1.5 for the wastes). The incremental RCRA disposal costs should not be understated with this assumption.

The calculation of net income is presented in Table 11-4. In general, the model firm has a good profit picture. The firm is assumed to be consistently able to earn $0.50 for each drum processed. The relatively rosy profile for the firm is consistent with the current fortunes of the industry which include good earnings and extremely high utilization rates for most firms.

The worst-case firm will be assumed to have a lower earnings rate. It is assumed to be able to make only $0.40/drum handled. The lower earnings can be attributed to greater average capital charges due to a lower capacity utilization rate. The relatively modest drop in earnings among these firms is again an indicator of the apparently strong market conditions in the industry. The worst-case firm will also be assumed to generate approximately 20 percent more solid waste than the model firm. A description of the model plant is also provided in Table 11-4.

### TABLE 11-4

### MODEL AND WORST-CASE DRUM RECONDITIONING FIRMS[a]

| | MODEL FIRM | WORST-CASE |
|---|---|---|
| Annual volume[b] | 240,000 drums | 240,000 drums |
| Gross revenue | $1,080,000 | $1,080,000 |
| Cost of operations net of solid waste disposal | $952,100 | $964,000 |
| Current disposal costs | $7,900 | $10,000 |
| Pre-tax net income | $120,000 | $96,000 |

[a] ERCO estimate.

[b] It is assumed that 4% of the incoming drums fail the reconditioning process and are sold for scrap.

## NOTES TO CHAPTER ELEVEN

1. Based on personnal communication between John Eyraud of ERCO and Robert Evans of Evans Barrel and Drum, June 14, 1978.

2. Based on the statement of ERCO and Morris Hershson of the National Barrel and Drum Association to the Resource Conservation Committee, November 17, 1977.

3. The calculation is based on "Pollution Abatement Expenditures, A Microeconomic Impact Report for SIC Group 5085 (Steel Drum Reconditioning Industry)," by W&A Industries. This source estimated reconditioning volume at 73 million in 1974 including the volume at 21 user-reconditioning plants. It was assumed that 20 percent of the industry volume is handled by user-reconditioning firms, on the assumption that user-reconditioning plants are larger than the average industry firm. Then, with a 6 percent growth rate, industry volume in 1977 is approximately 70 million drums. The actual production rate could be as high as 90 million, based on this information. At $9.00 per unit, estimated sales volume is $630 million. Other industry spokesmen dispute that volume has risen significantly over 50 million.

4. Personal communication between William Humm of ERCO and Joseph Hooper of Waymire Drum Co., Downing, California, October 26, 1977.

5. Arthur D. Little, Economic Analysis of Pesticide Disposal Methods, EPA, 1977.

6. Based on personal communications with a number of drum reconditioners.

7. ERCO estimate based on statements by a number of industry executives that price increases could be readily passed on to consumers.

8. Prussing, John E. and Laurel Lunt Prussing, "Energy Requirements of Steel Drum Manufacturing and Reconditioning," National Barrel and Drum Association, February 1974.

9. Personal communication between William Humm of ERCO and Joseph Hooper of Waymire Drum Co., October 26, 1977.

10. Assuming that each of the four largest firms can handle 5,000 drums per day and that they operate 250 days/ year, the four firms would process 5 million of a total of

60 million drums. Using an average of 4,000 drums per day for the largest firms, the total handled is 8 million.

11. Estimates are based on the geographical distribution of the membership of the National Barrel and Drum Association. The membership of the association does not cover the entire industry, and estimates were increased accordingly.

12. Personal communication between John Eyraud of ERCO and Morris Hershon oF NBADA.

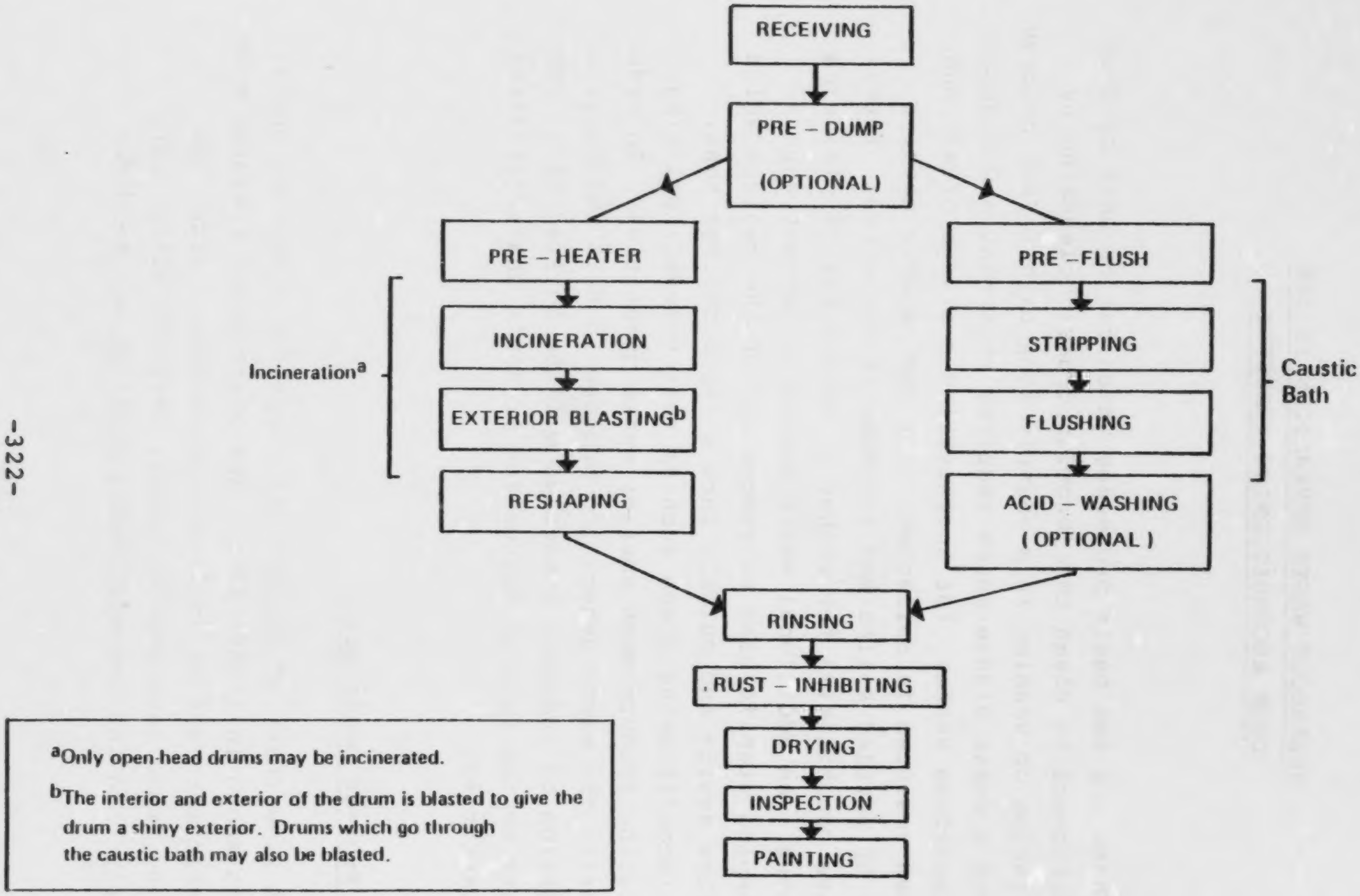
# CHAPTER TWELVE

# HAZARDOUS WASTE GENERATION IN THE DRUM RECONDITIONING INDUSTRY

There are two basic processes which can be used by drum reconditioners to clean the incoming drums: cleansing by incineration or washing in a caustic soda bath. Each process produces a waste sludge which requires treatment and disposal as a hazardous waste. For incineration a sludge of ash and unburned residues is collected. For the caustic bath, a sludge of settled solids and residues is collected. Firms may have capabilities for either or both types of cleansing processes. An additional waste source is present when a pre-dumping step is used to remove any of the residue which will flow easily and quickly into a waste storage tank. Other reconditioning steps such as rust removal, painting, and coating produce much smaller waste quantities. In order to clarify the waste generation process in this industry, a description of industry processes will be covered as a preliminary to the further discussion of waste characteristics and quantities.

## 12.1 Process Description

A flow chart of the process steps for a typical operation is shown in Figure 12-1. The plant shown operates both a caustic bath and an incineration process. After the incoming drums have been unloaded, they are either sent directly into the reconditioning plant or are held for


RECEIVING
PRE – DUMP (OPTIONAL)
PRE – HEATER
INCINERATION
EXTERIOR BLASTING^b
RESHAPING
Incineration^a
PRE – FLUSH
STRIPPING
FLUSHING
ACID – WASHING ( OPTIONAL )
Caustic Bath
RINSING
RUST – INHIBITING
DRYING
INSPECTION
PAINTING

[a] Only open-head drums may be incinerated.

[b] The interior and exterior of the drum is blasted to give the drum a shiny exterior. Drums which go through the caustic bath may also be blasted.

Figure 12 – 1. Process flow-chart for drum reconditioning plant.

pre-dumping. It has been estimated that about 50 percent of the industry operators choose to pre-dump and 50 percent do not.[1] The advantage of pre-dumping is that a smaller waste volume need be extracted by the reconditioning processes. Also fuel and chemical costs are reduced because a smaller amount of waste is burned or washed from the drum. The disadvantage of pre-dumping is the increased labor cost of an additional handling step. The issue is partially side-stepped by firms which direct their drivers not to accept drums with substantial waste quantities. If this is done, pre-dumping is less likely.

The decision as to whether a drum is to go through the incinerator or through the caustic bath depends on the type of drum and the expected difficulty of cleaning. The open-head drums have a removable top which allows them to be readily incinerated. The tight-head, or "bung," drums are fitted with a removable plug stopper of several inches in diameter. Because the drum head is secure, this type cannot be incinerated. The caustic bath method, in which spray nozzles are inserted through the plug hole for washing the inside, is then used.

When the open-head drums are incinerated, they are placed bottom-up on a conveyor belt and carried first to a preheater where viscous material is allowed to fall into a trough beneath the moving grate. The trough extends along the line through the incinerator where ash and partially combusted material collects. The incinerators used are fired with either gas or oil. Operating temperatures of 1,000° F to 1,600°F (538° C to 871° C) are common. After incineration the drums are transferred to a separate chamber for blasting. Steel shot and grit are ricocheted off the drum to give it a shiny, new-looking appearance. Dents in the drums are then removed before they go to rinsing.

For the caustic soda bath, drums are also inverted on a moving conveyor belt. Revolving spray nozzles are inserted into the drum to dispense the heated bath solution. The drums may be flushed twice in this fashion (the pre-flush and flush steps noted in Figure 12-1). If the normal bath is not sufficient for cleaning, lengths of chain are inserted into the plug-hole and the drum is submerged in the hot caustic solution. The drum is then removed from the bath and rotated, allowing the chains to scour the interior. These drums are returned to the main conveyor line and the drum exteriors are then sprayed with caustic in order to remove paint and labelling. The drum is then rinsed, sometimes with a neutralizing agent, and dried. Firms which are not equipped for the most difficult cleaning jobs may convert the tight-head drums to open-head in order to allow incineration. Others choose not to accept difficult jobs or to sell such drums to other reconditioning firms. For example, several firms which specialize in oil drums choose not to handle the more hard-to-clean drums.

It had been common practice in the industry to discharge wastes from the caustic soda bath into the sewer. However, many municipal treatment systems have adjusted their user charge system in order to levy greater fees on firms discharging large amounts of suspended solids. As a result, most industry firms are now attempting to control the solid materials discharged. Some firms pretreat their wastewater which normally consists of allowing solids to settle out of solution. A few firms use "zero-discharge" systems wherein very little suspended solids are discharged to the sewer. In either case, a caustic sludge is produced.

## 12.2 Waste Characteristics

Three principal waste streams are evident in the reconditioning process: (1) wastes from the pre-dump (excess material from the incoming drums), which are collected in a storage tank or in drums for disposal; (2) ash and sludge (unburned material) accumulated from the incinerator; and (3) settled or filtered material from the caustic soda bath. Other plant waste streams, which are very small, include a small amount of paint waste and excess chemicals from plants which bake a lining into some of the drums handled.

The most notable characteristic of reconditioning wastes is the wide variability in composition from plant to plant, and from hour to hour within a given plant. The nature of all of these wastes is largely determined by the mix of drums being handled. For example, the ash/sludge from the incinerator includes unburned and burned drum residues. The caustic sludge solids are likewise dependent on the drum residue being washed out during cleaning operations. The pre-dump wastes are totally a function of the drum sources.

Judging from the major sources of drums, conclusions can be drawn about the potential hazards of these wastes. The major sources (and customers), as mentioned in the previous chapters, are the oil industry, chemical firms and paint manufacturers. A number of substances from these industries, including various chemicals, hydraulic oils, and paint wastes, have been listed as hazardous in the RCRA Section 3001 regulations. Additionally the caustic soda bath often includes toxic chemicals such as muriatic acid, sodium nitrate and various paint solvents such as toluene, xylene and naphtha.[2] These highly toxic materials would be evident in pretreatment sludges. The wastes of the reconditioning industry can therefore be concluded to be hazardous.

The assumption that these waste streams are hazardous is consistent with industry acknowledgment that it has little control over the nature of incoming materials. The drums sent for reconditioning are often unlabeled and the customer does not care to identify the materials remaining in the drum. A number of industry contacts mentioned that even when a drum is labeled, the label is often inaccurate. A drum may be used for several purposes before eventual disposal.

In selected cases the variability of the waste streams is reduced because the firm has only a few industrial clients. Firms are often located near major markets such as petroleum refineries or chemical plants. However, most small firms receive a variety of drums from even their limited sources. For example, drums from a single chemical or paint manufacturer will contain a variety of material. It appeared that all of the firms contacted would be generators of hazardous wastes, as defined under RCRA.

## 12.3 Hazardous Waste Quantities

Drum reconditioner firms were surveyed to determine the average quantities of waste materials to be disposed. The waste quantities are presented in the context of the model plant. The model plant can handle 1,000 drums/day, and for convenience, is assumed to be operating at capacity. All of the drums received are pre-dumped. Half of the drums are incinerated and half are washed in the caustic bath. The firm is assumed to have a "zero-discharge" system and is disposing of caustic sludge. A key volumetric assumption is that the caustic sludge has been concentrated to 30 percent solids with a centrifuge or filler press. Also, the incinerator ash is assumed to be approximately 50 percent liquid (dry ash quantities alone are approximately half of those shown). The estimates developed are shown below in Table 12-1. The difference in waste quantities between caustic sludge and incinerator sludge appears to occur due to the different types of material likely to go through each process. More viscous materials are placed in open-head drums which are reconditioned by incineration. The more viscous materials leave a greater volume of residue per drum. Also, a portion of the wastes from the caustic bath are often discharged to the sewer. Only those firms with "zero-discharge" systems are completely capturing the suspended solids in the caustic bath.

TABLE 12-1

HAZARDOUS WASTE GENERATION AT MODEL DRUM RECONDITIONING PLANT[a]

| | QUANTITY PER DAY (number of 55-gal drums) | | |
|---|---|---|---|
| WASTE | LOW | AVERAGE | HIGH |
| Pre-dump | 3 | 5 | 7 |
| Caustic sludge | 0.5 | 0.8 | 0.5 |
| Incinerator sludge/ash | 2 | 4 | 6 |

[a] ERCO estimates.

Ranges are provided for each estimate to reflect variances in firm experiences. However, the ranges are also useful to denote the range at a given plant due to day-to-day differences in the drums handled. All of the waste-stream volumes are affected by the amount of residue in incoming drums. Many firms have reduced this variance by encouraging customers to empty their drums and by instructing drivers not to accept drums with 2 or more gallons of material. Virtually no firms appeared to have waste quantities which were consistently at the high range of the scale shown.

In order to develop national waste quantities a correction was made in pre-dump quantities to reflect the scope of industry practices. Specifically, only an estimated 50 percent of industry firms are pre-dumping drum wastes. For the remainder, the absence of a pre-dump step is reflected in only moderate increases in caustic sludge or ash quantities. The following waste quantities were estimated to be representative for one-half of the industry volume: pre-dump wastes - 0; caustic sludge wastes - 1 drum/day; incinerator ash/sludge - 5 drums/day. The estimate of caustic bath and incinerator wastes were thus increased by 20 percent over those for a firm with a pre-dump step. This estimate is somewhat theoretical in that discussions with industry personnel did not indicate a clear increase in process waste volumes for firms without a pre-dump step. The resulting estimates of aggregate waste quantities are shown in Table 12-2.

To estimate the total weight of wastes, a specific gravity of 1.5 was assumed. Many sludges have lower specific gravities, but ash tends to have a higher specific gravity.[3] With this assumption, the total wet weight of industry wastes is estimated at 170,000 metric tons.

The average waste quantities for the model firm with a pre-dump step is 3.0 MT per day. Without a pre-dump step, however, average waste quantities are 1.9. An overall average of 2.4 MT per day will be used for measuring economic impacts. The worst-case firm will be assumed to dispose of an even

### TABLE 12-2

### NATIONALLY GENERATED HAZARDOUS WASTES BY DRUM RECONDITIONERS[a]

| | ESTIMATED WASTE QUANTITIES (number of 55-gal drums) |
|---|---|
| Pre-dump | 175,000 |
| Caustic sludge | 63,000 |
| Incinerator ash/sludge | 315,000 |
| Total | 553,000 |

[a] ERCO estimate.

10 drums of waste, or 3.1 MT. This value represents a waste generation rate which is well above the industry average.

Before moving on, it is useful to discuss two groups of firms which have below-average waste generation rates. The first group handles only oil drums. These firms avoid any drums which present difficult cleaning chores. Oil drums can be reconditioned with relative ease and with minimal waste generation. Pre-dump wastes are often sold to waste oil collectors. Oil residues can be incinerated more completely than other wastes.[4] As a group, firms specializing in oil drums appear to have waste volumes which are roughly half those of the model plant.

The second group consists of many of the small, older firms in the industry. These firms often do not pre-dump wastes. Most are also discharging some of their wastes to the sewer. As a result, relatively minor volumes of solid waste are generated. This group of firms represents 15 to 25 percent of the industry firms. The oil drum firms and these small firms will both incur below-average RCRA impacts.

## 12.4 Number of Generators

As noted in Chapter Eleven, there are from 180 to 190 firms in the industry. All industry firms appear to be generators. The higher number, 190, will be used to represent the number of generators in the industry throughout the remainder of this report.

## 12.5 Current Disposal Practices

Current disposal practices frequently consist of a reliance on contracted disposal for landfilling of solid wastes. Alternative disposal practices have been and are being used, however, particularly for caustic sludge and pre-dump. This section will cover an assessment of the state of disposal practices. A summary of wastes and disposal practices is provided in Table 12-3.

Since a large number of reconditioners are in the industrial zones of urban areas, most have been using municipal sewers to handle as much of their waste stream as possible. This is particularly true with wastes from the caustic bath. Since the sludge drawn off the bottom of a settling tank is only 5 to 10 percent solids, it is easily pumped into the sewer. Where sewer user fees have been based on the volume of effluent alone rather than the loading of total suspended solids, this method of caustic sludge disposal has been much less costly than dewatering the sludge and then landfilling it. The industry is finding, however, that these low user fees for discharge into municipal sewers are rapidly becoming a thing of the past. Annual charges to many plants have increased by factors of

TABLE 12-3

SUMMARY OF WASTES
AND DISPOSAL PRACTICES[a]

| WASTE STREAM | CHARACTERISTICS | CURRENT DISPOSAL | RCRA SPECIFIED DISPOSAL |
|---|---|---|---|
| Pre-dump | Contains various hazardous wastes, toxic | Landfilled or incinerated | Secure landfill or controlled incineration |
| Caustic sludge | Contains various hazardous wastes, toxic, corrosive | To municipal sewer, municipal or private landfill | Secure landfill |
| Incinerator ash/sludge | Contains various hazardous wastes, toxic | Municipal or private landfill | Secure landfill |

[a] ERCO estimates.

from 10 to as much as 50 when sewer districts compute their charges on the cost of treating a particular effluent.[5]

Whereas some operators are switching from an effluent disposal of caustic sludge to a landfill disposal (i.e., a change from a liquid waste to a solid waste) because of dramatically increasing user fees, others are doing so because sewer districts are refusing to accept the untreated effluent. The operator is faced with three choices: building a pretreatment facility, dewatering the caustic sludge for landfilling, or ceasing operations. A few large facilities are building pretreatment facilities. Most, however, believe that their best hope lies in minimizing or eliminating their discharge of suspended solids. Some experimentation with zero-discharge systems is under way and is being watched with considerable interest by the larger firms. These decisions, though beneficial from a wastewater management point of view, add to the volume of material which the firms will have to landfill. However, the "zero discharge" systems appear to increase sludge quantities only slightly above those generated by more rudimentary pre-treatment facilities.

Pre-dump material is handled in a variety of ways. In a few cases it can be segregated as the drums are emptied so that materials with a commercial value can be sold. That practice, however, is the exception. Typically it is landfilled or incinerated. Some plants are experimenting with using oil and solvent pre-dump as a fuel supplement in their drum incinerators, though such a conversion can be plagued with design and operating problems.

Incinerator sludge/ash is landfilled. A few reconditioners practice on-site disposal, but this is uncommon. For a variety of reasons, most prefer to contract with a hauler who provides dumpsters which he periodically hauls to a landfill.

### 12.6 RCRA Required Disposal Practices

With the implementation of RCRA, reconditioning firms will be classified as hazardous waste generators and will be required to upgrade disposal practices. It is assumed that most firms will continue to contract for waste disposal. Appropriate waste disposal consists of secure landfilling for these waste materials. Economic impacts will consist of increased contractor disposal costs and the costs of complying with administrative aspects of RCRA. These factors are discussed in the following chapter.

### 12.7 Disposal Costs

All reconditioners will be assumed to be using contractors for off-site disposal in a secure landfill. The cost of off-site disposal will be taken from the study by Battelle for EPA.[6] The landfill cost from that source is $55.00/MT.

Administrative costs are given in Table 12-4. The costs were not annualized due to the small difference between first-year and recurring costs. First-year administrative costs are used in the analysis of economic impacts. It was assumed that all work would be performed by supervisory personnel and clerical staff. No testing costs were included due to the futility of testing the highly variable waste streams from drum reconditioners.

## TABLE 12-4

## ADMINISTRATIVE COSTS OF COMPLIANCE WITH RCRA FOR DRUM RECONDITIONERS[a]

| | LABOR | | | |
|---|---|---|---|---|
| | SUPER-VISORY ($25/hr) | CLERICAL ($8/hr) | OPTION A COST ($) | OPTION B COST ($) |
| Section 3001 | | | | |
| 1. Initial waste inventory | 8 | - | 200 | 200 |
| 2. Documentation of waste inventory | 7 | 6 | 223 | 223 |
| Section 3002 | | | | |
| 1. ID code application | 1 | 1/2 | 29 | 29 |
| 2. Quarterly and annual reporting | | | | |
| Option A | 12 | 32 | 556/yr | - |
| Option B | 5 | 13 | - | 229/yr |
| 3. Storage of manifests | - | - | 20/yr | 20/yr |
| 4. Manifest handling ($3/manifest, 1 manifest/mo) | - | - | 36/yr | 36/yr |
| 5. System design for labeling, manifesting, reporting, and identification of TSDF | 30 | 21 | 918 | 918 |
| 6. Ongoing super-vision | 24 | - | 600/yr | 600/yr |
| 7. Maintenance of hazardous waste list and refine-ment of other procedures | 4 | - | 100/yr | 100/yr |
| Total cost (first year) | | | $2,682 | $2,355 |
| Recurring annual costs[b] | | | $1,312/yr | $ 985 |

[a] ERCO estimates.

[b] Recurring costs are denoted by $/yr cost figures.

## NOTES TO CHAPTER TWELVE

1. Personal communication between John Eyraud of ERCO and Morris Hershson of the National Barrel and Drum Association.

2. William L. Rosbe, Memorandum to the National Barrel and Drum Association, October 28, 1977.

3. Battelle Columbus Laboratories, Cost of Compliance with Hazardous Waste Management Regulations, May 1978. A specific gravity of 1.2 was used as typical of most sludges. The specific gravity of dry oil ash is 2.5.

4. Personal communication between John Eyraud of ERCO and Bernard Klein of Kingsland Drum and Barrel Co. Inc., Newark, November 8, 1978. Other firms which are handling oil drums reported relatively small waste volumes.

5. Personal communication between William Humm of ERCO and Joseph Hooper of Waymire Drum Co., Downey, California and Morris Hershson of NBADA, September 29, 1978.

6. Battelle Columbus Laboratories, Cost of Compliance with Hazardous Waste Management Regulations.

## CHAPTER THIRTEEN

## ECONOMIC IMPACTS ON THE DRUM RECONDITIONING INDUSTRY

The discussion of industry impacts is divided into three sections. The first will provide a description of model RCRA impacts on the model and worst-case firms. In this analysis, it is assumed that prices and sales remain constant. In this way the incremental cost of compliance will be measured. The second section presents aggregate impacts. A third section looks at industry-wide impacts including the possibility of plant closures and job losses. For this section, the likelihood of price increases to pass through incremental costs is considered.

### 13.1 Model Plant Impacts

The waste quantities generated by the model and worst-case firms were described in the previous chapter. The model firm is assumed to be disposing of 2.4 MT of waste per day, compared to 3.1 MT for the worst-case firm. Off-site contractor disposal is expected to be used by both firms with the implementation of RCRA.

The impact of increased disposal costs under RCRA (Option A) on net income is shown in Table 13-1. The impacts shown assume that no price increases are made to cover increased costs. As is immediately evident, the cost increases are very significant. Disposal costs are estimated to rise from the current level of $13.10 per metric ton to

**Preceding page blank**

## TABLE 13-1

## IMPACTS ON THE DRUM RECONDITIONING MODEL FIRMS (OPTION A)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales | 1,080,000 | 1,080,000 |
| Cost of operations | 960,000 | 984,000 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 25,100 | 32,600 |
| Administrative costs[b] | 2,700 | 2,700 |
| Pretax net income | 92,200 | 60,700 |
| Pretax net income (before RCRA) | 120,000 | 96,000 |
| Decline in net income | 23% | 37% |

[a] ERCO estimates.

[b] Represents first-year administrative costs. Recurring annual costs are estimated at $1,312.

$55.00 per metric ton. Administrative costs are estimated at $2,700 for drum reconditioners under Option A. The total increase in costs is $27,800 over the estimated current disposal costs. The reduction in model and worst-case plant income is 23 percent and 37 percent respectively.

RCRA impacts under Option B are very much similar. Option B administrative costs are slightly lower due to decreased reporting requirements for generators in the September 1978 version of Section 3002. The impacts on net income as shown in Table 13-2 are 23 percent and 36 percent for the model and worst-case firm.

## TABLE 13-2

## IMPACTS ON THE DRUM RECONDITIONING MODEL FIRMS (OPTION B)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales | 1,080,000 | 1,080,000 |
| Cost of operations | 960,000 | 984,000 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 25,100 | 32,600 |
| Administrative costs[b] | 2,400 | 2,400 |
| Pretax net income | 92,500 | 61,000 |
| Pretax net Income (before RCRA) | 120,000 | 96,000 |
| Decline in net income | 23% | 36% |

[a] ERCO estimates.

[b] Represents estimated first-year administrative costs. Recurring annual costs are estimated at $985.

One caveat to these results should be mentioned. Worst-case firm impacts are based on a set of pessimistic assumptions. Very few firms appear likely to face such impacts, although comprehensive industry data on earnings are not available.

Second, a number of factors clearly indicate that price changes and other factors will ameliorate the impacts on net income. These are described in the next section.

### 13.2 Aggregate Impacts

Aggregate cost impacts are shown in Table 13-3. The sum of technical and administrative disposal costs is $7.6 million and $7.5 million for Options A and B. The RCRA

### TABLE 13-3

### AGGREGATE COST OF COMPLIANCE FOR THE DRUM RECONDITIONING INDUSTRY ($MM)[a,b]

| | OPTION A | OPTION B |
|---|---|---|
| Technical | 7.1 | 7.1 |
| Administrative[b] | 0.5 | 0.4 |
| Total[b] | 7.6 | 7.5 |
| 1977 production value | 640 | 640 |
| Costs as a percentage of production value | 1.2% | 1.2% |

[a] ERCO estimates.

[b] First-year administrative costs are shown. Recurring administrative costs are $0.2 MM for both Options A and B, reducing total cost by less than 5% in succeeding years.

compliance costs amount to 1.2 percent of 1977 production value in each case.

## 13.3 Industry Impacts

The analysis of model and worst-case firm impacts indicate potentially serious RCRA impacts for the industry. The worst-case impacts, in particular, suggest that a number of plant closures are possible. Net income for the worst-case plant is still positive, but with the sharp decline in income, the rate of earnings may be judged insufficient for continuing operations.

Several factors will act to reduce the likelihood of a large number of plant closures. The most important are:

(1) the likelihood of full-cost pass-through; (2) the relatively small waste disposal problems of small firms; and (3) some flexibility in the mode of operation which will allow firms to reduce impacts. These are discussed below.

The current market outlook for reconditioned drums is strongly positive. Demand for reconditioned drums is high relative to capacity and many firms have undertaken to expand their facilities. A price increase in reconditioned drums sufficient to cover the RCRA impacts is not expected to disrupt the optimistic outlook. Reconditioned drums are currently selling for from $4 to $6 less than new drums, which are the primary substitutes. A price increase of 10 to 15 cents per reconditioned drum does not seriously affect this differential. This price increase represents 2 to 3 percent of the cost of the reconditioning service.

Under most regulatory impacts, small firms are most likely to close down. However, as discussed in the previous chapter, a number of small firms may not pre-dump incoming drums and often are discharging much waste to the sewer.

If sewer discharges are pretreated, then a quantity of caustic sludge will need to be landfilled. In any case, the solid waste generated is small. As noted for the model plant, the quantities of caustic sludge are small relative to incinerator ash/sludge. RCRA impacts for these small firms are likely to be significantly below those of the model plant. Impacts may be more serious to the extent that RCRA impacts are piggybacked upon local pretreatment regulations for effluent discharges. However, the latter is likely to be a more substantial problem and thus these impacts are due to legislation other than RCRA. In summary, many of the industry's small firms face below average

RCRA impacts. The number of firms with the characteristics described above is estimated at 15 to 25 percent of the industry.

A summary of industry impacts is shown in Table 13-4. With regard to the likelihood of plant closure, it is estimated that there is a 25 to 50 percent probability that 10 percent of the industry's plants will close due to RCRA impacts. Production cutbacks appear unlikely, however, since firms are most likely to close due to competitive pressures. Other local firms should be able to increase production to take in the additional business.

TABLE 13-4

POTENTIAL ECONOMIC IMPACTS ON DRUM RECONDITIONERS
SUMMARY OF IMPACTS ON THE DRUM RECONDITIONING INDUSTRY

| | OPTION A | OPTION B |
|---|---|---|
| Number of generators | 190 | 190 |
| Plant closures | Possible | Possible |
| Job losses | Possible | Possible |
| Production cutbacks | Unlikely | Unlikely |
| Price increases | Small | Small |
| U.S. demand reduction | Small | Small |
| Balance of payments effects | None | None |

The price impact is described as small (estimated above at 2 to 3 percent of the total). The small price increase should not disrupt the strong growth of U.S. demand.

# PART V

# CHEMICAL WHOLESALING

# CHAPTER FOURTEEN

# CHARACTERIZATION OF THE CHEMICAL WHOLESALING INDUSTRY

## 14.1 Introduction

As a wholesaling industry, those companies in the chemical distributing business face many conditions and problems common to all wholesalers. Wholesalers buy and sell merchandise and also provide transportation, storage (warehousing), market information, financing, product standardization, and some disposal and preprocessing services to their customers. They usually serve customers who cannot, or prefer not, to buy in quantity directly from producers.

Small volume waste streams are generated in chemical warehouses in the process of repackaging chemicals. These wastes consist of any of a number of chemical products. Many of the chemicals are likely to be hazardous wastes and thus this industry has been examined.

The description of the industry provided below is divided into four sections. These are (1) the size and scope of the industry, (2) industry and market structure, (3) financial performance and (4) model plant description. This last section develops the analytic tool to be used for later analysis of the industry.

**Preceding page blank**

## 14.2 Size and Scope of the Chemical Wholesaling Industry

### 14.2.1 Industry Definition

The chemicals and allied products wholesaling industry under study here (SIC 5161) distributes chemicals such as acids, industrial chemicals, dyestuffs, industrial salts, plastic materials, rosin and turpentine. Not included in this industry are those companies which distribute primarily ammunition (SIC 5041); agricultural chemicals and pesticides (SIC 5122); and paints and varnishes (SIC 5198). However, chemical wholesalers may carry small amounts of products from these other SIC codes.

The 1972 Census reported approximately 6,400 chemical wholesaling establishments, owned and operated by 4,275 firms. Ninety percent of the firms run only one establishment, but the rest of the units, 2,500, are operated by 400 firms. It is estimated that 120 firms each own more than 25 establishments.

There are three types of chemical distributing firms: merchant wholesalers, manufacturers' sales branches and sales offices, and merchandise agents and brokers. Of these, only merchant wholesalers and manufacturers' sales branches have warehouse space.

Manufacturers' sales offices and merchandise agent and broker establishments rarely physically handle chemicals. Most of the manufacturers' outlets only process sales orders; distributing and warehousing operations are the responsibilities of other divisions within the chemical manufacturing companies.[1] The merchandise agents and brokers usually conduct third party sales. In this type of transaction, the wholesaler never sees the merchandise, but sells it for one party to another, usually without taking title, and arranges its transfer from the manufacturer to the customer. Agents and brokers are generally used only by small chemical manufacturers, by foreign companies selling chemicals in the United States, and by producers of specialty chemicals.[2]

Wastes are generated on a routine basis only for firms performing repackaging operations. Most of these firms are classified within the merchant wholesalers group. The merchant wholesalers are also likely to be making third party sales to some customers. Where possible, in the sections below, the discussion will be focused on this industry segment.

### 14.2.2 Chemical Wholesaling Sales

In 1972, the combined sales of the three chemical distributing segments were $24.6 billion. The manufacturers' outlets, accounting for only 25 percent of the number of outlets, made the majority of the sales, 78 percent. Merchant wholesalers accounted for 66 percent of the number of outlets, but only 18 percent of the sales. The agents and brokers, the smallest segment in all respects, represented 9 percent of the establishments and 3 percent of total sales.[3] A summary of the sales figures is provided in Table 14-1. The combined sales of the SIC 5161 segments account for approximately half of all United States chemical sales. Most of the remaining sales are made by the chemical manufacturers but do not go through their sales offices and branches. Small amounts of chemicals are sold by other SIC groups like retailers and metal service centers.

## TABLE 14-1

## CHEMICAL WHOLESALING INDUSTRY - NUMBER OF ESTABLISHMENTS, SALES AND EMPLOYMENT FIGURES, 1972[a]

| INDUSTRY SEGMENT | NUMBER OF ESTABLISH-MENTS | NUMBER OF FIRMS | SALES ($ billion) | NUMBER OF EMPLOYEES |
|---|---|---|---|---|
| Merchant wholesalers | 4,204 | NA | 4.587 | 38,401 |
| Manufacturers' sales branches and sales offices | 1,605 | NA | 19.198 | 36,452 |
| Merchandise agents and brokers | 588 | NA | 0.836 | 3,010 |
| Total | 6,397 | 4,275 | 24.621 | 77,863 |

[a] Department of Commerce, Bureau of Census, Census of Wholesale Trade, 1972.

Most of the independent chemical wholesalers are small companies which cover a limited geographical area and have regional sales of less than $1 million.[4] Nearly 60 percent of the merchant wholesaling operations have five or fewer employees whereas only 2 percent have more than 50 employees. Nevertheless, the large firms account for 16 percent of the total sales volume. The units with fewer than five employees make only 19 percent of the sales. The size distribution of the industry firms is provided in Table 14-2.

## TABLE 14-2

## MERCHANT WHOLESALERS - EMPLOYMENT LEVEL OF ESTABLISHMENTS 1972[a]

| NUMBER OF EMPLOYEES | PERCENT OF ESTABLISHMENTS | PERCENT OF TOTAL INDUSTRY SALES |
|---|---|---|
| 0-5 | 58 | 19 |
| 6-14 | 25 | 26 |
| 15-50 | 15 | 39 |
| >50 | 2 | 16 |
| Total | 100 | 100 |

[a] Department of Commerce, Bureau of Census, Census of Wholesale Trade, 1972.

Most of the independents carry 10-30 product lines, but some large firms carry many hundreds of product lines.[5] The number of product lines is a function of the markets being served. Since it is common for an individual firm to serve a few specialized markets, only a small number of chemicals will be carried. Distributors' product lines will tend to reflect the character of local industries.

The independents supply storage, transportation, location conveniences, repacking, and, in some cases, waste disposal services to their customers. Most product properties and applications are usually well known to the customer, thus little technical assistance or consulting is required.[6] However, the distributors do provide inventory services for their customers, many of whom are too small to keep large inventories. The customers pay a premium for these services: distributor prices may be from 5 to 40 percent higher than manufacturers' prices.[7]

Most chemicals are intermediate goods sold to other manufacturers who process them into end products. Large volume customers include the textile, rubber, paint, paper, petroleum and food industries. As shown in Table 14-3, 67.8 percent of the chemical distributors' sales are to industrial users; the next two largest customer sectors are retailers and other wholesalers, and households and individuals represent a small market segment. Most large customers buy chemicals directly from the manufacturers or their sales offices, whereas the merchant wholesalers, the independents, serve primarily smaller users.

### 14.2.3 Employment and Regional Distribution of Firms

Total industry employment in 1972 was 77.9 thousand. The merchant wholesaling segment employed 49 percent of the industry's work force, the manufacturers' outlet 47 percent, and the agents and brokers only 4 percent. Table 14-1 includes a summary of SIC 5161 sales, employment, and firm count statistics.

Firms are concentrated in urban, industrial areas. Generally firms are located near major customers in order to reduce transportation costs and improve the services

## TABLE 14-3

## PERCENTAGE DISTRIBUTION OF CHEMICAL WHOLESALERS' SALES BY TYPE OF CUSTOMER (1972)[a]

| INDUSTRY SEGMENT | INDUS-TRIAL USERS | FEDERAL, STATE, & LOCAL GOVERN-MENT | HOUSE-HOLDS & INDI-VIDUAL USERS | RETAILERS | WHOLE-SALERS | EXPORT | TOTAL[b] |
|---|---|---|---|---|---|---|---|
| Merchant wholesalers | 67.3 | 3.5 | 0.3 | 6.1 | 15.1 | 7.4 | 100 |
| Manufacturers' sales branches & offices | 67.9 | 1.6 | 0.4 | 13.6 | 12.7 | 3.6 | 100 |
| Merchandise agents & brokers | 68.2 | 1.5 | 0.1 | 4.4 | 18.4 | 7.1 | 100 |
| Industry as a whole[c] | 67.8 | 1.9 | 0.4 | 12.1 | 13.3 | 4.3 | 100 |

[a] Department of Commerce, Bureau of Census, Census of Wholesale Trade, 1972.

[b] May not total to 100 due to rounding.

[c] Sales weighted averages.

provided. The bulk of firms are located on the East and West Coasts and in the Upper Midwest.

## 14.3 Industry and Market Analysis for Chemical Merchant Wholesalers

The chemical distribution industry is characterized by a large number of firms, a lack of substantial barriers to entry and generally moderate profit margins. As such, it generally conforms to the competitive industry model of economic theory. In the sections below, basic components of industry structure and performance will be delineated.

### 14.3.1 Market Structure

Industrial purchasers of chemicals have a variety of paths available to them for securing necessary supplies. Depending on the type and quantity of chemical needed, the industrial consumer may order direct from the manufacturer, order through the manufacturers' sales offices or branches, or order through an independent chemical distributor. In major industrial areas, a significant number of firms can be possible points of contact. For exotic chemicals, fewer firms may serve the area but there appears to be some choice in most cases. One measure of the extent of choice is through examination of industry concentration ratios. However, concentration ratios are not developed by the Department of Census for wholesale or retail industries. Such ratios would, in any case, be uninformative at the national level and difficult to define at the local level. (Concentration ratios measure the percentage of industry sales handled by the largest firms, and are usually measured for 4 and 8 firms ratios.) Nevertheless, local concentration ratios appear to be low, although for small markets, such as for the specialized chemical needs of certain industries, they could be substantial. Even local concentration ratios would be misleading measures of market power to the extent that firms can order directly from the manufacturer.

Low concentration ratios indicate a general lack of market power and price setting power for firms. These market traits are generally accompanied by low barriers to entry and the resulting fact of a large number of small firms. Both of the latter characteristics are evident in this industry. Barriers to entry may consist of any market factor which restricts the entry of new firms. In most cases, the existence of barriers is a function of the size of the necessary capital investment for beginning operations. However, the small distributors serve mainly as transfer agents and small capital investments are often sufficient for operation. As the volume of material handled increases, additional investments are made in the equipment needed for repackaging.

A related aspect of market structure concerns the competition among independent merchant wholesalers and the distribution chains of major manufacturers. The relationship is only partially competitive. Major manufacturers tend to rely on wholesalers to serve small customers and often will not sell small volumes of material. Wholesalers are then used as a marketing tool, and are encouraged to carry the major firm's products. Technical advice and assistance may also be provided. On the other hand, manufacturers and independents compete for large accounts. Manufacturers can offer lower prices and discounts, while the distributor offers a variety of related services. In general, the partitioning of the market between large and small users provides an opportunity for small and independent distributors to prosper.

### 14.3.2 Market Conduct and Performance

Industry practices indicate a generally high level of price competition. The highest product price mark-ups appear to exist on the periphery of the industry; that is, for sales of specialized chemicals to small-volume users. Purchasers in outlying areas also may pay higher prices for chemicals due to the lack of proximity to distributors in urban areas. These groups of customers will tend to have least recourse to switching suppliers or to maintaining large chemical inventories. Product price mark-ups in the industry vary from 5 to 20 percent, and could go still higher in isolated cases.

Sales from merchant wholesalers have been increasing in recent years, but profits have not grown quickly due to cost increases and competitive pressures. A major factor behind the sales increase is that many customers have been choosing to reduce inventories as a cost-reducing measure. Reduced inventories generally indicate a shift toward reliance on a local chemical distributor. The peak in distributor profits occurred in 1974-1975 when a brief shortage of petrochemicals led to rapid price increases. Before-tax profit margins for that period averaged from 5 to 10 percent for small firms to 10 percent and over for larger firms. The statistics are taken from income tax reporting wherein income is reported in the most pessimistic form possible.[8] After 1974-1975, profits declined slightly, but general profitability appears to be average to above average.

## 14.4 Financial Profile

The operating costs for chemical distributors, as for other distributors, are largely determined by the cost of material purchased. The operating costs and margins for chemical distributors are shown in Table 14-4. The cost of operations, largely chemical purchases and payroll costs, range from 75 to 79 percent of sales for the asset size categories shown. Chemical purchase costs are not broken out separately, but are estimated to represent all but 5 to 10 percent of the cost of operations.

The before-tax profit figures shown are above-average figures for the industry. The reporting period used, 1974-1975, was a peak year for chemical distributors due to sharp rises in chemical prices. However, indications are that profits have declined only slightly since the 1974-1975 peak.[9] The figures indicate higher profitability for large chemical distributors. The higher volume firms are typically thought to be more profitable partly due to economies of scale in packaging and transporting operations. However, these conclusions are not supported by the data shown since the cost of operations is similar across firm sizes. Large firms may also tend to dominate large-volume sales in local markets, allowing them a measure of price-setting power. Higher average mark-ups would, of course, raise profit levels. Finally, the data sample shown indicates relatively less spending on several indirect expense items for large companies.

## TABLE 14-4

## OPERATING COSTS AND MARGINS - CHEMICAL AND DRUG DISTRIBUTORS
## (JULY 1974 TO JUNE 1975)
## (OPERATING STATISTICS AS PERCENT OF SALES)[a]

| | ASSET SIZE ($000) | | | |
|---|---|---|---|---|
| | <250 | 250-1,000 | 1,000-5,000 | OVER 5,000 |
| Cost of operations | 75.0 | 76.0 | 79.0 | 79.0 |
| Other expenses | 13.0 | 11.0 | 9.0 | 7.0 |
| Compensation of officers | 4.0 | 3.0 | 2.0 | 1.5 |
| Non-federal taxes, interest, depreciation | 1.5 | 2.5 | 2.0 | 1.5 |
| Rent, repairs | 1.0 | 1.0 | 1.0 | 0.5 |
| Pensions, other overhead expenses | 0.5 | 1.0 | 1.0 | 0.5 |
| Net profit before tax | 4.0 | 5.5 | 6.0 | 10.0 |

---

[a] Leo J. Troy, Almanac of Business and Industrial Financial Statistics, 1978.

Financial ratios for the same sample of distribution companies are shown in Table 14-5. The ratios are average for wholesaling industries. The current ratio (current assets/current liabilities) is in the vicinity of 2 for all asset size classes. A current ratio of 2 generally indicates a healthy balance sheet since, if necessary, current assets can be liquidated to cover current liabilities.

The inventory turnover rate of 10 to 11 times a year indicates that materials generally can be moved quickly (that is, inventory actually is liquid). This rate corresponds to a complete inventory change almost every month.

## 14.5 Model Firm Characterization

For the purposes of economic impact analysis, two model firms have been developed.

The model firms for chemical warehouses are characterized in Table 14-6. Although some large chemical distributors are multi-establishment firms, the majority of distributors are single-establishment firms. Thus, both the representative and worst-case model firms are given as single-establishment firms that engage in repackaging a proportion of their product.

Sales for the representative and worst-case firms are based on a sample of repackaging firms that are members of the National Association of Chemical Distributors (NACD).

## TABLE 14-5

## FINANCIAL RATIOS - CHEMICAL AND DRUG DISTRIBUTORS (JULY 1974 TO JUNE 1975)[a]

| | ASSET SIZE ($000) | | | |
|---|---|---|---|---|
| | <250 | 250-1,000 | 1,000-5,000 | OVER 5,000 |
| Current ratio | 2.1 | 1.8 | 1.8 | 1.9 |
| Quick ratio | 1.3 | 1.2 | 1.1 | 1.3 |
| Net sales/net working capital | 11.0 | 9.0 | 8.5 | 7.5 |
| Net sales/net worth | 10.0 | 7.0 | 6.9 | 5.4 |
| Inventory turnover | 11.1 | 9.5 | 9.5 | 9.7 |
| Total liabilities to net worth | 1.2 | 1.2 | 1.2 | 1.0 |
| Net income to net worth | 37.0 | 37.0 | 35.1 | 46.7 |

---

[a] Leo J. Troy, Almanac of Business and Industrial Financial Statistics (in some categories, reported categories were not identical to the asset size categories used here; reported categories were averaged to derive these numbers).

## TABLE 14-6

## MODEL FIRM CHARACTERIZATION FOR A CHEMICAL WAREHOUSE[a]

| | 1978 DATA ($000) | |
|---|---|---|
| NUMBER OF WAREHOUSES: 1 | MODEL FIRM | WORST-CASE FIRM |
| Sales | $10,000.00 | $5,000.00 |
| Cost of sales, expenses | 9,319.00 | 4,865.00 |
| Cost of disposal | 0 | 0 |
| Profit (before tax) | $ 680.30 | $ 134.00 |

[a]ERCO estimates based on 1 warehouse.

The NACD represents approximately 50 percent of the industry wholesalers. The sales volume of member firms ranges from $5 to $10 million. Accordingly, the model firm has been assumed to have a sales volume of $10 million and the worst-case firm sales of $5 million.

Net profit before taxes was obtained from a percentage financial breakdown developed by Robert Morris Assoc.

A profit rate of 6.8 percent was chosen for the model plant. This figure was the mean value for an 80-firm sample with assets ranging from $1 to $10 million and average sales volume of $8.6 million. For the worst-case firm, a low 2.7 percent profit was used. This figure was the mean of a 67-firm sample with assets from $250,000 to $2 million and mean sales of $2.1 million.

## NOTES TO CHAPTER FOURTEEN

[1] Personal communication between Alisa Gravitz of ERCO and marketing and distribution personnel of the major chemical manufacturers, week of July 31, 1978.

[2] Kline Guide to the Chemical Industry, Charles Kline & Co., New Jersey, 1974, p. 44.

[3] Department of Commerce, Census of Wholesale Trade, 1972.

[4] Kline Guide to the Chemical Industry, Charles Kline & Co., New Jersey, 1974, p. 43-44.

[5] Kline Guide to the Chemical Industry, Charles Kline & Co., New Jersey, 1974, p. 43-44.

[6] Leo J. Troy, Almanac of Business and Financial Statistics.

[7] "Chemical Distributors," Chemical Week, December 15, 1976.

[8] Personal communication between Steve Fischer of ERCO and Paul Guthrie of the National Association of Chemical Distributors, October 1978.

# CHAPTER FIFTEEN

## HAZARDOUS WASTE GENERATION IN THE CHEMICAL WHOLESALING INDUSTRY

The wastes that chemical warehouses generate are for the most part only residual product that is generated in the repackaging and transfer stage of their operations. In the distribution of chemicals only some materials need be repackaged. Estimates shown below indicate that the volume of repackaging wastes, relative to total volume, is very small.

This chapter will address the basic characteristics, quantities, and disposal means for wastes in the chemical industry. In addition, changes which will be necessary in disposal techniques under the Option A and Option B versions of RCRA will be specified.

### 15.1 Process Description

Nearly all routinely generated wastes at chemical warehouses are in liquid form. Dry chemicals are received by warehouses in prepackaged form and are not broken down into smaller containers for customers. Liquids, which are received in bulk containers or in drums (55-gallon drums), can be shipped out as is or can be broken down into smaller containers for customers.

The repackaging of liquids generates almost all of the waste from distributors. Depending upon the method of repackaging, the waste quantities can vary substantially. Repackaging methods encountered tend to vary with the firm size, with larger firms practicing much more careful control over waste generation.

The largest firms contacted reported no waste generation from repackaging. For each liquid chemical which is repackaged a separate reversible pump and line is used for transfer. When the required amount of chemical is transferred from the bulk container (railroad car, tank truck, or storage tank) to another container, the pumps are reversed and the line is cleared of the remaining chemical. The hoses and lines are then detached and allowed to air dry. The bulk storage tanks are located below ground and the transfer is done subsurface to control vapor loss.[1]

Other large firms also exhibited strict control of their wastes from repackaging. These firms do not use reversible pumps, but have less capital-intensive methods of waste control. At these firms,the lines used to transfer chemicals are first drained to clear the remaining chemical from the line. The drained chemical is put into a holding drum marked for storage. The accumulated volume of a chemical is then used as raw product at some later date. The hoses and lines, when used for the transfer of different chemicals, are steam-cleaned and then allowed to air dry.[2]

Smaller firms are least able to control repackaging wastes. In general, each hose is used to transfer a number of different chemicals. The expense of separate lines for each chemical is not justified by sales volumes. When the chemical being repackaged is changed, the new product is flushed through the line to clear it of the previous chemical. The first two to five gallons of chemicals are collected as waste. Some firms will then pool this waste into drums, which are saved for periodic waste disposal. Other firms simply deposit the waste down a dry well, a floor drain to a sewer, or other outfall.

In all cases, the chemical distributors are motivated to some degree by economics. For larger firms, who handle greater volumes of chemicals, the expense of having separate pumps and lines for each chemical is less than the gains in product sales they realize from limiting the loss of their product. For smaller firms, the volume of chemicals lost is not sufficient to pay for the expense of establishing more stringent controls to limit repackaging wastes.

The only other waste streams for chemical warehouses are occasional spills of chemicals. Spilled materials are generally recovered, washed into the sewer, or allowed to evaporate. From discussions with industry personnel it appears that the volume of spilled materials is very minor.

## 15.2 Waste Characteristics

As mentioned in Section 15.1, the wastes generated from chemical distributors result from repackaging liquids. Chemical distributors tend to be specialized in the products they sell, so the wastes from firm to firm will obviously vary. Among the industry, however, the major liquids that are repackaged can be classified into one of three basic groups. These are:

1. Organic and inorganic solvents
2. Acids
3. Caustic solutions

### 15.2.1 Organic Solvents

A wide variety of solvents are offered by chemical distributors. Many of the solvents are flammable as defined by Section 3001 of RCRA, and thus can be regarded as hazardous. In addition, many of the solvents supplied by distributors appear on the EPA list of priority pollutants, and are therefore hazardous. Since those firms that generate solvent wastes do not generally segregate them (except as chlorinated or non-chlorinated for disposal purposes), any solvent waste stream will be considered hazardous for RCRA purpses.

### 15.2.2 Acids

Chemical distributors supply large amounts of acids to industrial users. Although individual product volumes are not available, sulfuric acid and nitric acid are the two most common acids suppled by distributors. Other acids distributed in large volumes are hydrochloric and hydrofluoric acid. Most acids, unless significantly diluted, are likely to fail corrosivity tests and reactibility tests specified in Section 3001 of RCRA, and are thus regarded as hazardous wastes. As is the case with solvents, all acid wastes will be regarded as hazardous. The volume of acids repackaged is generally smaller than the volume of solvents repackaged.

### 15.2.3 Caustic Solutions

Liquid caustic solutions are the only caustics routinely repackaged. Sodium hydroxide and ammonium hydroxide solutions are two of the most common caustic solutions distributed. These solutions, as well as other caustic solutions in general, will fail the corrosivity and reactivity tests of Section 3001, and thus are regarded as hazardous wastes.

### 15.3 Model Plant Waste Quantities

The typical chemical distributor is a firm that covers a limited geographical area, stocks chemicals that have diffuse end uses, and relies on the markup between bulk shipments bought directly from manufacturers and the smaller retail quantities sold to each customer.

Before proceeding to the typical waste quantity figures, several points of relevance to the estimation procedure must be noted. First, the amount of waste per liter of product repackaged varies according to the degree of control the firm exercises over the repackaging process. According to firms contacted, the waste collected was 1 percent or less of the total product repackaged if a large number of different chemicals were handled in succession. A figure of 0.75 is estimated for normal operations. This figure will be used as the estimate for the amount of waste generated per unit of repackaged material. Second, the total amount of wastes depends largely upon the amount of liquids repackaged.[4] Estimates of the total percentage of liquids repackaged ranged from approximately 15 to 75 percent of the liquid chemicals that are at some point warehoused at the distributor's facility.[5]

Third, the mix of dry and liquid chemicals varies between firms. Liquids are estimated to account for between 50 and

80 percent by weight of the total chemicals warehoused at the majority of chemical distributors.[6]

Fourth, distributors also arrange for sales directly between the manufacturer and the customer. For merchant wholesale distributors that maintain warehouses and repackaging facilities, the amount of direct business handled is estimated to range from 40 to 60 percent of their total weight of chemicals sold.[7]

Table 15-1 gives the waste quantity estimates based upon the following assumptions derived from conversations with distributors:

1. Wastes are 0.75 percent of repackaged material.
2. Forty percent of the liquids are repackaged.
3. Liquids are 75 percent of the warehoused chemicals, dry chemicals are 25 percent.
4. Fifty percent of total business is handled directly and does not move through the warehouse.
5. Sales volume is $10,000,000/year (1978), and the volume of repackaged liquids is 1,800,000 liters per year.

According to the assumptions above, 1,125 liters of waste chemicals are generated per month. This amount is enough to fill approximately six 208-liter (55-gallon) drums per month with waste chemicals. Although this amount is assumed to be 0.75 percent of the repackaged material, it represents less than one-tenth of one percent of weight of the total chemicals sold by a typical distributor.

For the worst-case firm, only two parameters were changed in order to estimate waste quantities. First, the size of

## TABLE 15-1

## TYPICAL WASTE GENERATION - CHEMICAL DISTRIBUTOR

| | PER MONTH | | PER YEAR | |
|---|---|---|---|---|
| | LITERS | KILOGRAMS[a] | LITERS | KILOGRAMS[a] |
| Waste | 1,125 | 1,406 | 13,500 | 16,875 |
| Repackaged liquid | 150,000 | 187,500 | 1,800,000 | 2,250,000 |
| Total liquids handled at distributor's facility | 375,000 | 468,750 | 4,500,000 | 5,625,000 |
| Total chemicals handled at distributor's facility | NA | 625,000 | NA | 7,500,000 |
| Total chemicals sold by distributor | NA | 1,250,000 | | 15,000,000 |

[a] Based on 1.25 specific gravity.

[b] NA = not applicable; includes dry chemicals measured by weight only.

the firm was halved, because a smaller firm can be expected to be more susceptible to any adverse impacts RCRA might impose upon them. Second, a waste generation rate of 1 percent of repackaged liquids was assumed. All other relative proportions were unchanged. Table 15-2 shows the waste generation for the worst-case firm.

## TABLE 15-2

## WORST-CASE WASTE GENERATION - CHEMICAL DISTRIBUTORS

| | PER MONTH | | PER YEAR | |
|---|---|---|---|---|
| | LITERS | KILOGRAMS[a] | LITERS | KILOGRAMS[a] |
| Waste | 750 | 937.5 | 9,000 | 11,250 |
| Repackaged liquids | 75,000 | 93,750 | 900,000 | 1,125,000 |
| Total liquids handled at distributor's facility | 187,500 | 234,375 | 2,250,000 | 2,812,500 |
| Total chemicals handled at distributor's facility | NA[b] | 312,500 | NA | 3,750,000 |
| Total chemicals sold by distributor | NA | 625,000 | NA | 7,500,000 |

[a] Based on 1.25 specific gravity.

[b] NA - not applicable; includes dry chemicals measured by weight only.

### 15.4 Aggregate Waste Quantities

The model firm and the worst-case firm are assumed to comprise the range of characteristics of the majority of the generators in the industry. Thus, the estimate of aggregate waste quantities is based upon an average of the model firm and the worst-case firm waste quantities and the number of generators in the industry. Using this basis, Table 15-3 shows the estimate of aggregate hazardous waste quantities from the 360 chemical distributors identified as generators.

TABLE 15-3

AGGREGATE WASTE QUANTITIES - CHEMICAL DISTRIBUTORS

| PER MONTH | | PER YEAR | |
|---|---|---|---|
| LITERS | KILOGRAMS[a] | LITERS | KILOGRAMS[a] |
| 337,500 | 421,875 | 4,050,000 | 5,062,500 |

[a] Based upon 1.25 specific gravity.

## 15.5 Number of Generators

Census figures indicate that 4,204 merchant wholesalers in the SIC 5161 class were in operation in 1972. Of this group, 2,504 firms reported that they had warehouse space. Of these, only a small percentage repackage their chemicals, as most function mainly as a warehouse for prepackaged goods. The best estimate, based largely upon conversations with the National Association of Chemical Distributors, indicates that approximately 400 firms in 1977 repackage the chemicals they handle. It is assumed that these firms are the only ones that have the potential for generating hazardous wastes in quantities that would classify them as a generator under proposed RCRA statutes.

Contacts with chemical distributors indicate that not all potential generators do in fact generate sufficient wastes to be classified as a generator. As mentioned in Section 15.1, the largest repackaging firms have controls on their procedures that virtually eliminate routine waste of their material.[8] Ten percent of the firms in the industry are estimated to be large enough to have instituted strict controls on their waste generation. Thus, the total number of generators is estimated to be 90 percent of 400, or 360.[9]

An estimated 20 percent (70) of hazardous waste generators practice waste control procedures that will satisfy RCRA disposal. These firms collect their wastes in drums and send them to hazardous waste disposal firms. Those firms that dispose of their wastes down dry wells, sewers or watercourses are estimated to account for the remaining 290 firms classed as generators.[10]

## 15.6 Current Disposal Practices

Current disposal practices show varying degrees of environmental concern. The disposal methods encountered in the course of this study included:

1. Disposal of wastes from line flushing directly into dry well.
2. Neutralizing treatment for spills (especially acids) which are flushed down into a dry well, sewer line or water course.
3. Collection of wastes in drums and subsequent consignment to a hazardous waste disposal facility.
4. Reclaiming of some chemicals (especially used solvents returned by customer) by sending them to chemical reclaimers. The reclaimed chemical is then sold back to the original user or to someone else.

Where there is no routine waste, occasional spills are the only sources of waste. These spills are diluted, neutralized if possible, and often allowed to flow down a drain. in the case of volatile solvents, small spills are sometimes left to evaporate.

### 15.7 RCRA Specified Disposal - Options A and B

As is the case with the other industries in this study two versions of proposed RCRA legislation are being reviewed for their economic impact. Option A and Option B versions will be examined for their impact upon the chemical distributors. This section will deal with the changes in the actual disposal of the chemical waste necessitated by the proposed RCRA action.

According to Section 3002 of both Options A and B, generators must send hazardous waste to a treatment, storage, or disposal facility permitted by the EPA. These facilities will either reclaim, incinerate, or deposit the wastes in a secured landfill. Distributors who are currently disposing of their wastes down dry wells or into sewers will be required to cease such procedures and come into compliance with RCRA. However, this change is not one that necessarily requires a large alteration in the method of doing business.

Instead of allowing wastes to run free down the dry well during flushing, the material can be collected in a small container and transferred to a drum for storage. Many firms already practice this procedure. After a period of time, the wastes that have been accumulated must then be sent to a hazardous waste disposal facility.

Because of disposal practices and the nature of the chemicals involved, some segregation of the wastes is necessary. For example, many solvents are incinerated for disposal. However, chlorinated solvents are more difficult (and more expensive) to dispose of than non-chlorinated solvents. Chlorine in the solvent combines with hydrogen during incineration to form highly corrosive hydrochloric acid (HCl). Other hydrogenated solvents have similar provisions, and their disposal is consequently more difficult as well. Thus, waste disposal firms that incinerate solvents suggest segregation of the two wastes.

To comply with the proposed RCRA regulations, distributors could also institute practices to eliminate wastes. As mentioned in Section 15.2, these procedures usually involve the installation of reversing pumps, separate repackaging lines for each chemical or class of chemicals, and temporary storage facilities for residual chemicals. The necessary investments, however, are expected to be prohibitively expensive for most firms and will not be considered here.

## 15.8 Costs of RCRA Compliance

### 15.8.1 Technical Costs of Compliance

For the model plant (see Section 16.1) it has been assumed that current practices do not include control of wastes to the degree required by RCRA. An estimated 290 (80 percent) of the generators are in this class. Thus, any wastes generated by these firms will have to be sent to a hazardous waste disposal firm in response to both Options A and B.

Current average costs for incineration (the method most likely to be used for the majority of wastes from distributors) are currently around $30 per drum ($1.15/kg) according to a study by Battelle Columbus Laboratories. This figure will be used to estimate RCRA-induced disposal costs. In addition, a $15 per drum charge will be added to account for the drums used for dispoal. Thus, a total disposal cost of $45/drum ($2.50/kg) will be used for technical costs of compliance. Table 15-4 shows the disposal costs for the model and worst-case firms. The estimates are calculated on the basis of 78 drums of waste per year from the model firm and 52 drums per year from the worst-case firm.

An estimated 70 firms (20 percent), now follow procedures that entail disposal of their wastes at hazardous waste disposal firms. For these firms, the incremental technical costs of compliance will be assumed to be zero.

TABLE 15-4

TECHNICAL DISPOSAL COSTS FOR CHEMICAL DISTRIBUTORS[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Waste quantity (drums) | 78 | 52 |
| Cost of disposal per drum | 45 | 45 |
| Yearly disposal cost | 3,510 | 2,340 |

[a] ERCO estimates.

### 15.8.2 Administrative Costs of Compliance

The agenda of administrative costs and tasks is shown in Table 15-5. It has been assumed that all of the administrative tasks will be performed by supervisory or clerical personnel. First-year compliance costs are estimated at $2,718 and $2,391 for Options A and B. Recurring annual costs are roughly half of first-year costs.

TABLE 15-5

ADMINISTRATIVE COSTS OF COMPLIANCE WITH RCRA FOR CHEMICAL WHOLESALERS[a]

| | SUPERVISORY ($25.00 hr) | CLERICAL ($8/hr) | OPTION A COST ($) | OPTION B COST($) |
|---|---|---|---|---|
| Section 3001 | | | | |
| 1. Initial waste inventory | 8 | - | 200 | 200 |
| 2. Documentation of waste inventory | 7 | 6 | 223 | 223 |
| Section 3002 | | | | |
| 1. I.D. code application | 1 | 1/2 | 29 | 29 |
| 2. Quarterly and annual reporting | | | | |
| Option A | 12 | 32 | 556/yr | - |
| Option B | 5 | 13 | - | 229/yr |
| 3. Storage of manifests | - | - | 20/yr | 20/yr |
| 4. Manifest handling[b] ($3/manifest) | - | - | 72/yr | 72/yr |
| 5. System design for labeling manifesting, quarterly reporting, and identification of TSDF | 30 | 21 | 918 | 918 |
| 6. Ongoing supervision | 24 | | 600/yr | 600/yr |
| 7. Maintenance of hazardous waste list | 4 | - | 100/yr | 100/yr |
| Total cost (first year) | - | - | 2,718 | 2,391 |
| Recurring annual costs[c] | - | - | 1,349 | 1,021 |

[a] ERCO estimates.

[b] Assumes 2 shipments of waste per month.

[c] Recurring year costs are denoted by $/yr figures.

# NOTES TO CHAPTER FIFTEEN

1. Personal communication between Steve Fischer of ERCO with Fred Akerlund of Van Waters and Rogers, Los Angeles, California, 21 August 1978.

2. Personal communication between Steve Fischer of ERCO with William Mann, Jr., George Mann and Company, Inc., Providence, Rhode Island, 19 September 1978.

3. Based on personal communication between Steve Fischer of ERCO and Paul Guthrie of the National Association of Chemical Distributors.

4. When chemical firms do not repackage, they merely act as a warehouse. Many customers need chemicals of high purity. These chemicals are containerized and sealed at the factory. Thus, waste streams primarily result from repackaging.

5. All estimates for repackaging, product mix, and sales are derived from discussions with distributors, manufacturers, and the National Association of Chemical Distributors. No published data were found.

6. Fifty to eighty percent constitutes the range of estimates given by chemical distributors contacted.

7. Again, this represents the range of estimates given by distributors contacted.

8. The claims of large firms as to their control of wastes were accepted. No independent information could be uncovered which invalidated these claims.

9. ERCO estimates based upon discussions with chemical distributors.

10. ERCO estimate. Based on responses to telephone interviews by chemical distributors.

11. Derived from cost of compliance with hazardous waste management regulation, Battelle Columbus Laboratories, 1978 and based upon a specific gravity of 1.25.

CHAPTER SIXTEEN

# ECONOMIC IMPACT ANALYSIS FOR THE CHEMICAL WHOLESALING INDUSTRY

The economic impacts of RCRA regulations on chemical wholesalers are described below. The first section describes the small model plant impacts for this industry. The model plant impacts are then used to develop aggregate compliance costs. A final section describes industry impacts.

## 16.1 Model Firm Impacts

Tables 16-1 and 16-2 detail the economic impacts on the model firms developed for the analysis. Table 16-1 displays Option A impacts, while Table 16-2 shows Option B impacts.

To calculate the model firm impacts the following assumptions were made:

1. Revenue costs and expenses (other than waste disposal) remain unchanged. In this way, one can compare the effects of the proposed RCRA legislation upon the present economic position of the firm.

2. Hazardous waste disposal is assumed to be accomplished by collection of wastes in steel drums. For disposal and safety reasons, the wastes are segregated by type of material. Post-RCRA disposal costs are estimated to be an average of $30 per

## TABLE 16-1

## IMPACTS ON CHEMICAL WHOLESALING MODEL FIRMS (OPTION A) (WITH REGULATION)

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales[a] | 10,000,000 | 5,000,000 |
| Cost of operations and expenses | 9,319,700 | 4,865,000 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 3,500 | 2,300 |
| Administrative costs[b] | 2,700 | 2,700 |
| Pretax net income | 674,100 | 130,000 |
| Pretax net income (before RCRA) | 680,300 | 135,000 |
| Decline in pretax net income | 1% | 4% |

[a] ERCO estimates.

[b] Assumes no change in price.

[c] First year administrative costs are shown. Recurring annual costs are $1,300.

## TABLE 16-2

## MODEL FIRM IMPACTS ON CHEMICAL WHOLESALING MODEL FIRMS (OPTION B) (WITH REGULATION)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales[a] | 10,000,000 | 5,000,000 |
| Cost of operations and expenses | 9,319,700 | 4,865,000 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 3,500 | 2,300 |
| Administrative costs[b] | 2,400 | 2,400 |
| Pretax net income | 674,400 | 130,300 |
| Pretax net income (before RCRA) | 680,300 | 135,000 |
| Decline in pretax net income | 1% | 3% |

[a] ERCO estimates.

[b] Assumes no change in price.

[c] First-year administrative costs are shown. Recurring annual costs are $1,000.

drum, with drum costs accounting for an additional $15 per drum. Thus, a total of $45 per drum is included for waste disposal costs. (See Section 15.9.1.)

3. Administrative costs, displayed in Table 15-5, are assumed to be relatively insensitive to differences in volume of wastes generated. Thus, administrative costs for both model firms are assumed to be equal.

The impacts under Option A, as shown in Table 16-1, are small. Option A impacts amount to 1 percent of net income for the model firm and 4 percent for the worst-case firm. The technical disposal costs account for 56 percent of the compliance costs for the model firm, while they account for 46 percent of RCRA compliance costs for the smaller worst-case firm. The administrative costs comprise a higher percentage of the costs for the smaller worst-case firm because of the assumption that administrative costs are not a function of firm size.

Option B impacts are very similar. The only change in compliance costs is due to a reduction in reporting requirements (administrative costs). The impact on the pretax net income of the worst-case firm is estimated to drop to 3 percent while for the model firm, compliance costs are again estimated at only 1 percent of net income.

## 16.2 Aggregate National Impacts

Table 16-3 displays national cost estimates based upon the assumption that the typical and worst-case firms comprise

### TABLE 16-3

### AGGREGATE COST OF COMPLIANCE FOR THE CHEMICAL WHOLESALING INDUSTRY (1977 $000)[a]

| | OPTION A | OPTION B |
|---|---|---|
| Technical disposal costs | 783 | 783 |
| Administrative costs | 972 | 864 |
| Total compliance costs[b] | 1,753 | 1,647 |
| 1977 sales (estimate) | 2,700,000 | 2,700,000 |
| Compliance as a percent of 1977 sales | 0.1 percent | 0.1 percent |

[a] ERCO estimate.

[b] Represents first-year administrative costs. Recurring administrative costs are $1,344,000 for Option A and $1,021,000 for Option B. This reduces total cost by 30% in succeeding years.

the range of characteristics of the majority of the generators in the industry.[1] The incremental technical disposal costs for the 70 firms estimated now to be collecting wastes have been assumed to be zero. Aggregate technical disposal costs are $783,000 under both options.[2]

Administrative costs will be incurred by all of the 360 current generators. Aggregate administrative costs are $972,00 and $864,000 under Options A and B. Total national sales from generators are estimated from the average sales of the model and worst-case firms. The estimate for the aggregate sales in 1977 is 2.7 billion dollars.

As can be seen, Options A and B differ only slightly in their total impact, and neither impact is expected to appreciably increase costs. Option A impacts are estimated to increase the costs to all generators in the first year by approximately 1.8 million dollars. This total represents less than one-tenth of one percent of all revenues from generators in 1977.

Option B impacts are estimated to require increased costs of only 1.6 million dollars in the first year. This represents less than one-tenth of one percent of 1977 revenues. Thus, as a percentage of sales, neither Option A nor Option B presents a cost of any significance.

## 16.3 Industry Impacts

Pretax net income will be decreased by RCRA compliance by a maximum of 4 percent for the model plants. As a percentage of the total sales of generators, the costs amount to no more than one-tenth of one percent. These costs are expected to have only minimal impacts on chemical distributors, and will require only minor adjustments in industry conduct.

Table 16-4 presents a summary of likely industry responses to the proposed RCRA regulations. Price increases are the most probable response, but these are expected to be only very minor. The extra costs imposed by RCRA are such a small proportion of sales that only very small price increases would be needed across the full line of chemicals handled or repackaged to cover the costs of waste disposal.

Because impacts are so small, no other significant response to RCRA regulations by distributors is foreseen.

## TABLE 16-4

## SUMMARY OF IMPACTS ON THE CHEMICAL WHOLESALING INDUSTRY[a]

| | OPTION A | OPTION B |
|---|---|---|
| Number of generators | 360 | 360 |
| Plant closures | Unlikely | Unlikely |
| Job losses | Unlikely | Unlikely |
| U.S. production cutbacks | Unlikely | Unlikely |
| Price increases | Small | Small |
| U.S. demand reduction | Small | Small |
| Balance of payments effects | None | None |

[a] ERCO estimates.

There will be added incentives to control the waste volumes, but the expenditures for controls cannot be expected to exceed the RCRA-imposed costs of waste disposal. Thus, any change in procedure will be minimal.

## NOTES TO CHAPTER SIXTEEN

1. The model and worst-case firms were constructed so as to span the characteristics of the majority of generators (see Chapter 15). Information obtained from distributors facilitated this construction. National aggregate impacts and sales for generators were estimated from an average of the model firm and worst-case firm.

# PART VI

# AGRICULTURAL SERVICES

# CHAPTER SEVENTEEN

# CHARACTERIZATION OF THE AGRICULTURAL SERVICES INDUSTRY

The sections below will present basic data on the agricultual services industry. The discussion is divided into four sections. First, the size and scope of the industry is outlined. Then, the industry structure and industry performance are covered. A third section presents the available financial data. A final section covers the model firms to be used for analysis.

## 17.1 The Scope of the Agricultural Services Industry

The agricultural services industry consists of firms which provide soil preparation services, crop planting services, and crop protection services to farms on a contract or fee basis. The industry is impacted by RCRA due to the generation of several pesticide-related wastes. The industry can be roughly defined by the four-digit Standard Industrial Classication (SIC) definitions listed below:[1]

1. SIC No. 0711 - Soil Preparation Services - Establishments engaged primarily in land breaking, the application of fertilizer, seed bed preparation, and other operations for breaking soil.

2. SIC No. 0721 - Crop Planting, Cultivating and Protection - Establishments engaged primarily in crop planting, cultivating, and protection services.

**Preceding page blank**

3. SIC No. 0729 - General Crop Services - Establishments engaged primarily in providing a combination of services concerning crop preparation and harvesting.

Among the activities included within the categories, those which are of greatest interest here involve the application of pesticides to farm land. The term "custom applicators" is used to describe those firms which specialize in the application of pesticides and fertilizers. The other major applicators are the farmers themselves. Custom applicators of pesticides handle the largest volumes of hazardous materials and generate the largest quantities of hazardous waste. Custom applicators can be roughly divided between aerial applicators and ground applicators. These two groups within the industry will be the focal points for detailed analysis.

The relative size of the major industry segments is shown in Table 17-1. The firms classified as general crop services are a very small part of the industry and were not included in the table. For soil preparation services, fertilizer and lime spreading and weed control account for 73 percent of the gross receipts in 1974. For crop services, aerial dusting and spraying accounted for 69 percent of the gross receipts, and on-ground dusting and spraying for another 5 percent. Thus, reported statistics on the agricultural industry refer principally to custom applicators. Data presented in later sections can be assumed to apply to this group although a few firms not involved with pesticide application may be included.

## TABLE 17-1

## DISTRIBUTION OF RECEIPTS AMONG TYPES OF AGRICULTURAL SERVICES ESTABLISHMENTS, 1974[a]

| TYPE OF AGRICULTURAL SERVICE | PERCENTAGE OF GROSS RECEIPTS |
|---|---|
| Soil Preparation Services | |
| Plowing or land breaking | 14 |
| Harrowing or seed bed preparation | 5 |
| Fertilizer and lime spreading before planting | 61 |
| Weed control before planting | 12 |
| Other | 8 |
| Crop Planting, Cultivation, and Protection | |
| Planting with or without fertilizer | 3 |
| Fertilizer spreading after planting | 7 |
| Aerial dusting and spraying for disease and insect control with and without fertilizer | 69 |
| On-ground dusting and spraying for disease and insect control with and without fertilizer | 5 |
| Weed control after planting | 9 |
| Citrus grove cultivation or maintenance | 4 |
| Cultivation, mechanical and flame, other than citrus grove | <1 |
| Pruning of orchards or vineyards | 1 |
| Other | 2 |

---

[a] *Census of Agriculture 1974, Special Report: Agricultural Services*, U.S. Dept. of Commerce, Bureau of the Census, p. 8.

### 17.1.1 Industry Sales and Growth

The agricultural services industry has been growing rapidly in recent years. The number of establishments has increased dramatically accompanied by a concomitant increase in industry sales. The number of establishments in the industry as measured in 1974, and as estimated in 1978, is shown in Table 17-2. Of particular note is the growth in the number of aerial applicators of pesticides. From a total of less than 1,000, current estimates put the number of active firms in 1978 at 3,800.[2] The increase over 4 years represents an annual growth rate of 38 percent. Estimates of the growth for other agricultural services can only be speculative. However, it is expected that a census of the industry for 1978 will indicate a substantial increase in the number of establishments.[3] An increase of one-third in the number of soil preparation and miscellaneous crop service firms was estimated for 1978. An increase of 150 percent in the number of firms classified as ground applicators (of pesticides) was assumed on the basis that growth has been quite rapid for this group. For the future, growth rates on the order of 10 to 12 percent are anticipated for custom applicators.[4]

Totalling across industry segments, the total number of agricultural service firms is estimated to be 6,300. If half of the soil preparation service firms handle significant pesticide volumes, the number of pesticide application firms is 5,300. As shown in Table 17-1, the role of pesticide application among soil preparation firms is fairly low. However, many of the firms which principally handle fertilizers also apply herbicides.

## TABLE 17-2
## NUMBER OF ESTABLISHMENTS AND GROSS RECEIPTS, 1974 AND 1978[a]

| TYPE OF AGRICULTURAL ESTABLISHMENT | 1974 | | 1978 ESTIMATES | |
|---|---|---|---|---|
| | NUMBER OF ESTABLISHMENTS | GROSS RECEIPTS FOR SERVICES ($000) | NUMBER OF ESTABLISHMENTS | GROSS RECEIPTS |
| Soil preparation services and miscellaneous crop protection services | 1,500[b] | 80,000[b] | 2,000 | NA[c] |
| Aerial applicators of pesticides | 931 | 105,500 | 3,800 | NA |
| Ground applicators of pesticides | 201 | 7,523 | 500 | NA |

[a] Census of Agriculture, 1974, Special Report: Agricultural Services, U.S. Dept. of Commerce, Bureau of the Census, p. 7; information provided by Fred Clyme of Econ, Inc.; and ERCO estimates.

[b] Approximate values.

[c] NA = not applicable.

The growth in the number of custom applicators, both aerial and ground, is related to the tightness in farm budgets. Fewer farmers are choosing to invest in pesticide application equipment, particularly as the technology has become more sophisticated and expensive. Custom applicators also provide personnel with more training and experience than the farmer is likely to have at his disposal. Furthermore, the rapid rate of regulatory change and product innovation have made it increasingly difficult for individual farmers to stay abreast of the pesticide field. Dealers and applicators maintain more specialized knowledge of the current regulations and products.

An additional reason for the widespread use of custom application services is the high opportunity cost to farmers of performing fertilizer and pesticide application themselves. Fertilizer and pesticide application is most useful when performed during the spring. However, in the spring, planting also requires a lot of the farmer's time. Farmers can put in an order to a custom applicator for fertilizer and pesticide application in one field of his farm and then spend his own time in another. This time factor has become increasingly important as the scale of agricultural operations has grown. The increase in farm size has added to the spring and summer chores for the farmer and made custom application more crucial.

Approximately one of four custom applicators also sell the fertilizer and pesticide materials which they then apply. The application of fertilizer is often provided as a service to a fertilizer customer. Similarly, pesticide sales and application are often provided jointly. Figures provided by the Census of Agriculture indicate that among firms which sell material, gross receipts total \$200,000 or more of fertilizer, lime, and pesticides within a year.[5] This figure is a reasonable approximation of the product sales total for both ground and aerial applicators. The data supporting these calculations are presented below in Table 17-3. The product sales figures are not broken down into the custom application categories, but virtually all the product sales (over 95 percent) were generated by fertilizer and pesticide sales.[6]

## TABLE 17-3

## GROSS RECEIPTS FOR SALES AND PRODUCTS FOR AGRICULTURAL SERVICES FIRMS, 1974[a]

| INDUSTRY CLASSIFICATION | ESTABLISH-MENTS REPORTING SERVICE SALES | GROSS RECEIPTS FOR SERVICE SALES ($) | AVERAGE RECEIPTS FOR SERVICES ($) | ESTABLISH-MENTS REPORTING PRODUCT SALES | GROSS RECEIPTS FOR PRODUCT SALES ($) | AVERAGE RECEIPTS FOR PRODUCT SALES ($) |
|---|---|---|---|---|---|---|
| All soil preparation services | 1,044 | 43,219,445 | 41,398 | 200 | 44,776,228 | 223,881 |
| Fertilizer & lime spreading before planting | 619 | 26,417,378 | 42,678 | | | |
| Weed control before planting | 277 | 5,222,125 | 18,852 | | | |
| All crop planting, cultivating, and protection services | 1,614 | 153,766,389 | 95,270 | 470 | 92,283,043 | 196,349 |
| Aerial dusting & spraying | 931 | 105,499,796 | 113,319 | | | |
| On-ground dusting & spraying | 201 | 7,522,656 | 37,426 | | | |

---

[a] Census of Agriculture, 1974, Special Report: Agricultural Services, U.S. Dept. of Commerce, Bureau of the Census.

### 17.1.2 Distribution of Agricultural Services Among Crops and Among Farm Regions

The importance of agricultural services, and specifically of custom applicators, varies widely depending on the crops being grown. Farming techniques are highly crop-specific. The trend toward increased use of agricultural services, as discussed in the previous section, has not been evenly distributed among farms. Rather, it has meant an uneven increase in use determined in each case by the specific economics of the region and crop. Table 17-4 displays the relative importance of custom application among crops. The crop showing the highest dependence on custom application is rice, with nearly all pesticides being applied by professional services. The dependence in this case is entirely on aerial application. Also, because careful seeding is not necessary, rice seeds are spread from the air during planting. Thus, aerial services are crucial to rice growing.

The other notable crop uses shown in Table 17-4 are corn and cotton. These are the largest volume applications of custom pesticides. Like rice, cotton is especially dependent on aerial application. The cotton crops need to be sprayed regularly during the year in order to limit the growth of boll weevils. Pesticides are applied to corn by either ground or aerial applicators.

The amount of pesticides applied for many crops is much more variable, depending on the yearly infestation of insects. Wheat, for example, may require a number of pesticide sprayings in a difficult year.

The regional distribution by gross receipts of all agricultural service firms is shown in Figure 17-1. The largest

## TABLE 17-4

## EXPENDITURES FOR CUSTOM APPLICATION OF PESTICIDES BY CROP, 1971[a]

| CROP | PERCENTAGE OF TOTAL PESTICIDE EXPENDITURES CUSTOM-APPLIED | TOTAL VALUE OF PESTICIDES CUSTOM-APPLIED ($000) |
|---|---|---|
| Rice | 95 | 16,160 |
| Alfalfa | 63 | 4,296 |
| Wheat | 62 | 12,419 |
| Sorghum | 53 | 20,444 |
| Summer fallow | 44 | 986 |
| Citrus | 43 | 9,197 |
| Other grains | 43 | 3,955 |
| Cotton | 39 | 51,324 |
| Other hay and storage | 38 | 219 |
| Other vegetables | 35 | 13,849 |
| Peanuts | 33 | 12,929 |
| Other field crops | 32 | 5,425 |
| Sugar beets | 27 | 3,944 |
| Pasture | 26 | 2,212 |
| Other fruits and nuts | 24 | 5,729 |
| Corn | 22 | 72,843 |
| Irish potatoes | 21 | 3,701 |
| Soybeans | 18 | 24,455 |
| Other deciduous fruits | 10 | 2,294 |
| Tobacco | 9 | 1,631 |
| Nursery and greenhouse | 3 | 175 |
| Apples | 1 | 193 |
| Total all crops | 28 | 268,380 |

---

[a] Farmers' Expenditures for Custom Pesticide Services, 1971, Walter J. Ferguson, Economic Research Service, U.S. Dept. of Agriculture, Agricultural Economic Report No. 314, p. 6.

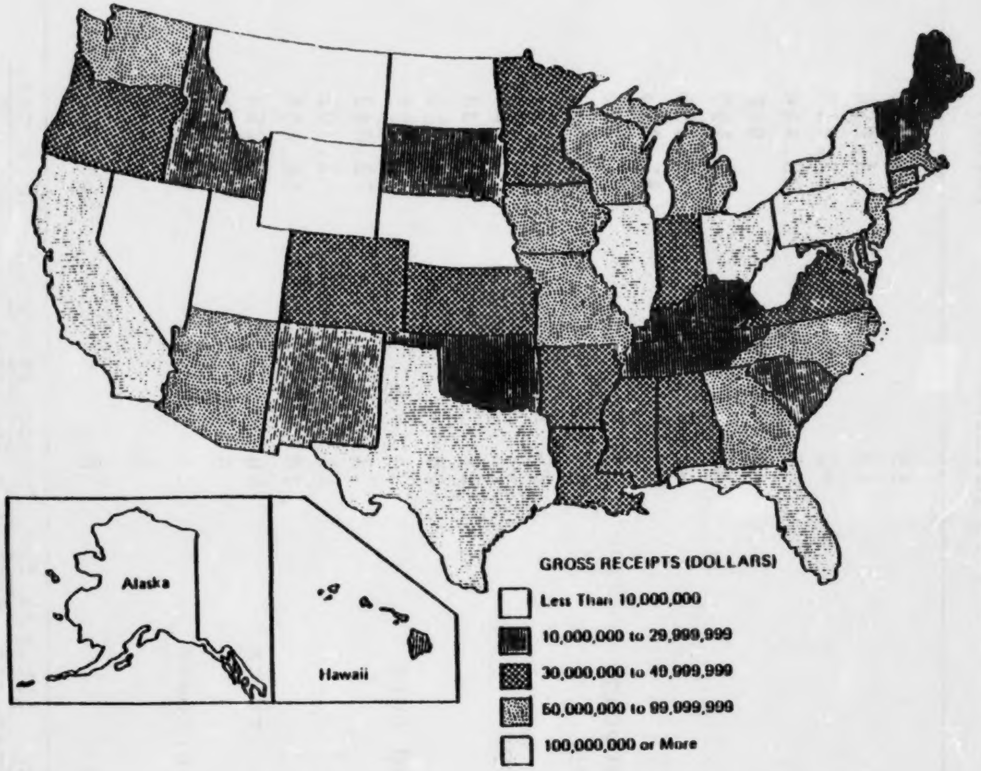

GROSS RECEIPTS (DOLLARS)
Less Than 10,000,000
10,000,000 to 29,999,999
30,000,000 to 49,999,999
50,000,000 to 99,999,999
100,000,000 or More
Alaska
Hawaii

Figure 17–1. Distribution by states of all agricultural services in the United States, 1974*. (*Census of Agriculture 1974, Special Report Agricultural Services,* U. S. Dept. of Commerce, Bureau of the Census, page 7.)

* Includes agricultural services other than soil preparation services and crop protection services (e.g. harvesting services).

agricultural states, e.g., California and Florida, are the states with the largest amount of contract agricultural services. In 1974 California registered $824 million of service activity. The second largest grossing state, Florida, had $359 million of service activity.

### 17.1.3 Industry Employment

Industry employment is characterized by a small number of employees per firm and by the seasonal nature of the work. Employment figures from the 1974 Census of Agriculture are presented in Table 17-5. Looking at the total number of paid workers in 1974, there were approximately 15,600 workers in 2,658 firms (see Table 17-2) for an average of 5.9 paid employees per firm. Of these, an average of 2.5 employees work less than 150 days a year. The average firm therefore has roughly 3 or 4 "full-time" employees. Additional information about the size distribution of firms is presented below in Section 17.1.4.

The importance of small operations in the industry is also indicated by the significant number of unpaid workers. The unpaid workers are typically family members of the owner-operator who do not draw salaries but indirectly share in company profits. In 1974 there were 1,458 such employees among the 2,658 firms or approximately one such worker for each two firms.

The significant number of paid workers who work less than 150 days a year indicates the presence of a casual labor group which can, during slow seasons, turn to other occupations. A portion of these workers may be family or friends of the owner-operators of the custom application firm, differing from the unpaid workers in that they are able to draw wages.

## TABLE 17-5

## EMPLOYMENT BY AGRICULTURAL SERVICE FIRMS[a]

| | CENSUS OF AGRICULTURE, 1974 | | | |
|---|---|---|---|---|
| | UNPAID WORKERS | | PAID WORKERS | |
| | ≥150 days | ≤150 days | ≥150 days | ≤150 days |
| Soil preparation services | 312 | 283 | 1,425 | 1,832 |
| Crop planting, cultivating, and protection | 496 | 367 | 5,512 | 6,865 |
| Totals | 808 | 650 | 6,937 | 8,697 |

[a] Census of Agriculture, 1974, Special Report: Agricultural Services, U.S. Dept. of Commerce, Bureau of the Census, p. 1.

In off-peak seasons these workers and the unpaid workers may leave the labor force for other activities such as school or housework. However, some of the seasonal workers are pilots who can find other employment for much of the year. In rural areas near large cities, many pilots provide air taxi services out of city airports. Various other occupations, such as aerial photography, are also second (or first) careers for these pilots.

### 17.1.4 Size Distribution of Firms

The number of small and large firms in the industry can be determined through examination of the available figures on firm sales and assets. A size distribution of firms on the basis of their gross receipts for services is presented in Table 17-6. Only the receipts for services, and not those for product sales, are included. The size distribution curve for firms in both the soil and crop service categories is relatively flat. However, it is noteworthy that nearly one-half (46 percent) of the soil preparation service firms tallied receipts of less than $20,000. By comparison, only one-third of the crop service firms were as small. The largest category for crop service firms is the $100,000 to $499,999 group (1974 figures) which captured 31 percent of all firms.

Available statistics on firm organization types, presented in Table 17-7, indicate that the corporate organization is found much more frequently among the crop services (47 percent compared to 16 percent). Individual ownership is nevertheless very popular in the industry as a whole, being used by 62 percent of the soil preparation establishments and 44 percent of crop services.

Average asset size does not differ greatly between the two types of service industries. In each case, average asset size is fairly small. The largest establishments are those crop services which are corporations, and these had an average asset value of less than $200,000 in 1974.

For aerial application, some firms own a significant fleet of planes and provide services in several states. Such firms are, however, quite rare. More typical is a small operation with three or fewer airplanes. The model firms in the industry will be discussed further in Section 17.4.

## TABLE 17-6

## SIZE DISTRIBUTION OF AGRICULTURAL SERVICE ESTABLISHMENTS BY ANNUAL GROSS RECEIPTS FOR SERVICES

| | GROSS RECEIPTS ($) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | UNDER 10,000 | 10,000 to 19,999 | 20,000 to 29,999 | 30,000 to 49,000 | 50,000 to 99,999 | 100,000 to 499,000 | OVER 500,000 | ALL (%) |
| Soil preparation services | 26 | 20 | 10 | 15 | 13 | 15 | 1 | 100 |
| Crop planting, cultivating, and protection services | 10 | 10 | 9 | 14 | 23 | 31 | 3 | 100 |

[a] Census of Agriculture, 1974, Special Report: Agricultural Services, U.S. Dept. of Commerce, Bureau of the Census, p. 5.

## TABLE 17-7

### AVERAGE GROSS VALUE OF DEPRECIABLE ASSETS FOR AGRICULTURAL SERVICES FIRMS, BY TYPE OF OWNERSHIP[a]

| | PERCENTAGE OF ESTABLISHMENTS | AVERAGE GROSS VALUE OF DEPRECIABLE ASSETS ($) |
|---|---|---|
| Soil preparation services | | |
| Individual | 62 | 47,000 |
| Partnership | 22 | 92,000 |
| Corporation | 16 | 143,000 |
| Total | 100 | |
| Average | | 72,000 |
| Crop planting, cultivation, and preparation services | | |
| Individual | 44 | 56,000 |
| Partnership | 9 | 74,000 |
| Corporation | 47 | 182,000 |
| Total | 100 | |
| Average | | 117,000 |

[a] *Census of Agriculture, 1974, Special Report: Agricultural Services*, U.S. Dept. of Commerce, Bureau of the Census, p. 7.

## 17.2 Industry and Market Analysis

### 17.2.1 Industry Structure

The structure of the agriculture services industry is dominated by two features: (1) the absence of firms large enough to exercise much market power in national or regional markets and (2) the low barriers to entry. With regard to the first point, it is clear that no firms show sales volumes which are significant relative to the industry totals. No figures on the extent of industry concentration are available, but it is clear that the four largest firms would represent 2 percent or less of the industry sales. The size distribution of firms, shown above in Table 17-6, is flat over a wide range of size classes.

The lack of significant market power for large firms is common among service industries. Services cannot be shipped over long distances like commodities and, therefore, must be provided directly by a local establishment. A few firms run operations in a number of states, but each operation is centered around a local base. For ground applicators, services are likely to be provided only within a radius of 15 to 20 miles. For aerial applicators, the range of operations is greater but is nevertheless centered around a single base of operations. Within each radius of operations, a firm will generally be competing with several others.

The other significant determinant of industry structure consists of the low to moderate entry requirements for new firms. The most serious obstacle for new firms is obtaining capital for the basic investments. The average value of depreciable assets for individually owned firms (i.e., noncorporate forms of ownership) was roughly $50,000 in

1974, as stated in Table 17-7. In 1978, a more reasonable figure is $100,000 to $125,000, owing to increases in prices for basic assets. Modern ground application equipment costs $50,000 to $60,000 per unit. Airplane prices range from $60,000 to $100,000. These sums represent significant obstacles for new, small operations, but are not so large as to seriously inhibit entry, as was shown by the statistics on industry growth. Also, insurance costs have increased considerably for agricultural service firms to the point where they now represent a significant problem for some firms. Premiums have risen much faster than the rate of inflation as they have in other areas where the size of damage settlements has escalated.

Institutional barriers to entry also exist. For custom applicators of pesticides, certification from state agencies may be required. No such certification is required for firms involved only in fertilizer spreading. The certification procedure varies from state to state but generally involves a training course on basic pesticide handling procedures. For aerial applicators, adequate pilot training is also necessary.

Finally, the marketing costs associated with starting a new enterprise are small. Most operations cover only a small local area, so only local advertising would be needed. If the custom applicator is also selling the fertilizer or pesticide, then the customer could be informed of the service when he makes his purchase.

To summarize, the largest obstacle to entry is the capital which must be raised to purchase the basic assets. The capital requirements are, nevertheless, only moderate. Small additional costs are accrued in the course of obtaining necessary training in pesticide handling. Marketing costs are small. Overall, the entry requirements are not excessive for individuals to overcome in order to participate in the industry.

### 17.2.2 Industry Conduct

Industry pricing patterns are consistent with the competitive structure of the industry. Pricing is largely competitive. Firms are generally very aware of the possibility of price cutting by others in the area. As a group, aerial applicators can often be undercut by ground operators. There appears also to be substantial price competition within each group. Firms are, therefore, price takers, i.e., subject to the going rates for services that are set by the market.

Industry conduct is also shaped by its concern with receiving large amounts of repeat business. Repeat business is generated by quality service in addition to reasonable prices. Any damage to the crop due to insect infestation becomes largely the responsibility of the custom applicator. Serious crop damage could ruin the firm's reputation and sharply reduce his business volume.

### 17.2.3 Industry Performance

The industry trends with regard to prices and performance are consistent with the competitive industry model. No price indices are available, but the prices for agricultural services do not appear to be rising at an unusual rate. The depressed state of the agricultural economy in general has increased price competition for the industry.

The extremely large increase in the number of firms in the industry has also sustained the industry's competitive structure. As a result, the increase in demand for services has not been translated to a sizable extent into an increase in prices or an increase in the market power of existing firms. Because the barriers to entry in the form of investment and training requirements are small, it is relatively easy for new firms to enter the field in any region where profit rates are unusually high.

## 17.3 Financial Profile

No financial data were available on industry firms. Information on profit margins used in this report is based on discussion with industry personnel.

## 17.4 Economics of the Model Firms

The model firm is described here in terms of its economic characteristics. The model firm was chosen to represent the economic position of the typical operator. A smaller operation will be described below in order to measure worst-case impacts. Both the model and worst-case firms are aerial applicators. This segment of the industry was used for several reasons. First, aerial applicator firms are the largest industry segment. This group also does the great bulk of pesticide application. Also, more data were available on firm characteristics, particularly on the acreage covered per season.

The model firm is an aerial applicator operating in the Corn Belt. A description of the firm characteristics is shown in Table 17-8. The firm is assumed to operate three planes each for 300 hours during a 7-month season. (The firm employs three pilots, one of whom is also the owner, and a one-man ground crew.) The 7-month season is typical of agriculture in much of the nation, but is, of course, shorter than the growing season in California and in the South.

The average price paid per acre in the Corn Belt varies from $2 to $2.50 per acre. A price of $2.25 per acre has been used. The pretax net income of 8 percent of gross revenues is assumed. Discussions with industry personnel showed average profit margins to vary from 4 to 20 percent among firms. Wider variations may be observed depending on the year. The relatively modest profit margin was used here

TABLE 17-8

CUSTOM APPLICATOR MODEL FIRM [a]

| | |
|---|---|
| Type of firm | Aerial applicator |
| Total no. of aircraft | 3 |
| Hours flown[b] | 900 |
| Total acreage covered[b] | 90,000 |
| Average price per acre | $2.25 |
| Gross revenue | $202,500 |
| Cost of operations | $165,000 |
| Pretax net income | $16,200 |

[a] ERCO estimates.

[b] Derived from Operator Profiles developed by Fred Clyne, Econ, Inc.

because many operators felt that margins were often under 10 percent. The cost of operations is derived and the difference of gross revenues and assumed net income. Major expense items include salary and/or commissions for the pilots and ground crew, aircraft maintenance, workmen's compensation and liability insurance.

For worst-case impacts a small aerial applicator firm will be used. The firm is assumed to own only one aircraft which is flown by the owner-operator. The owner is assisted by a one-man ground crew. Again, the firm will be assumed to be operating in an area with a seven-month growing season. The firm is assumed to also be earning net income above and beyond the income paid to the owner-operator as salary and commissions. Basic data on the firm are shown in Table 17-9.

TABLE 17-9

CUSTOM APPLICATOR WORST-CASE FIRM[a]

| | |
|---|---|
| Type of firm | Aerial applicator |
| Total No. of aircraft | 1 |
| Hours flown[b] | 300 |
| Total acreage covered[b] | 30,000 |
| Average price per acre | $2.25 |
| Gross revenue | $67,500 |
| Cost of operations | $62,000 |
| Pretax net income | $5,400 |

[a] ERCO estimate.

[b] Derived from operator profiles developed by Fred Clyne, Econ, Inc.

The one-aircraft firm is very common in the industry. More importantly, these single aircraft operations are probably the most vulnerable firms in the industry. As with most industries, small firms are likely to be least able to withstand regulatory impacts.

## NOTES TO CHAPTER SEVENTEEN

1. Department of Commerce, Standard Industrial Classification Manual, 1972.

2. The ERCO estimate is based on telephone conversations between John Eyraud, ERCO, and Fred Clyne of Econ, Inc., June 1978. The Census Bureau puts the number of actual applicators at over 3,000, but more detailed estimates for 1978 were not available.

3. Personal communication between John Eyraud, ERCO, and B. Womack, Census Bureau, Department of Commerce, June 26, 1978.

4. Telephone conversation between John Eyraud, ERCO, and Harold Collins, National Agricultural Aviation Association, June 27, 1978.

5. Census of Agriculture, 1974, Special Report: Agricultural Services, U.S. Dept. of Commerce, Bureau of the Census, p. 6.

6. Detailed product sales figures are provided in the source material references in Table 8-3, but were excluded from this document.

7. Personal communication between John Eyraud, ERCO, and Harold Collins, National Agricultural Aviation Association, June 27, 1978.

8. Personal communication between John Eyraud, ERCO, and Paul Buchanon, Iowa Fertilizer and Chemical Association, July 10, 1978.

9. The assumption of a $2.25 price per acre yields a revenue equal to $67,500 per plane. The average revenue per plan varies by region. On the east coast, annual revenues by plane run to $40,000 to $50,000. In the South, $90,000 to $100,000 is common. Still higher revenues can be earned in California. The value of $67,500 was used here as an approximate average value.

# CHAPTER EIGHTEEN

# HAZARDOUS WASTE GENERATION IN THE AGRICULTURAL SERVICES INDUSTRY

In the following sections, the agricultural services industry is examined in terms of the generation of waste materials which come under the purview of RCRA. The potentially hazardous waste materials in this industry include unused waste pesticides, used pesticide containers, and dilute pesticide solutions generated as rinse water. The waste materials are highly toxic, and their disposal has been previously addressed with recommended practices under federal law (FIFRA) and by regulations from a number of state agencies.

The waste streams are generated by custom applicators of pesticides. These firms provide spraying and crop dusting services to farmers. Custom applicators of pesticides and fertilizers represent the bulk of the agricultural services. The following discussion will focus on this group.

The sections below will cover the nature and quantities of waste materials, the required treatments under RCRA, and the impact of RCRA on the average cost of disposal.

## 18.1 Waste Characteristics

The pesticides handled by the custom application industry are potent, biologically active chemicals which are generally toxic not only to the target pests but to non-target organisms.

**Preceding page blank**

As such, the disposal of waste pesticides and pesticide containers is a matter of some interest. In this section, information about the physical and chemical form of pesticides will be briefly discussed, along with a survey of any hazardous properties of the materials. The latter issue is largely one of toxicity.

The majority of pesticides are synthetic organic chemicals. A smaller group of pesticide materials is inorganic. The supply of inorganic pesticides is roughly one-ninth that of organic pesticides.

Pesticides are normally divided into three groups by function. These are herbicides, which control weed growth; insecticides, for pest control; and fungicides, to prevent the growth of fungus on the crops. The largest class by volume of use is herbicides, which accounted for 43 percent of total pesticide use in 1971. Insecticides accounted for 38 percent and fungicides for 19 percent.[1] However, fungicides are not used extensively on farmland.[2]

Pesticides are handled in a variety of dry and wet forms, and the variety available applies to each individual pesticide. A custom applicator can buy the most common pesticides as a liquid, wettable powder, dust, pellet-sized solid, or in a dry or liquid fertilizer mixture. In pure forms, most pesticides are solid and may or may not be soluble in water. A description of some of the basic properties for a number of chemicals is provided in Table 18-1 below. Pesticides which are insoluble in water will generally have a solvent or some other type of carrying agent if the material is applied in liquid form in the field. Generally speaking, the carrying agents will not affect the basic properties of the pesticide.[3]

## TABLE 18-1

## PROPERTIES OF SELECTED PESTICIDES[a]

| PRODUCT | PESTICIDE CLASS | PROPERTIES (SOLUBILITY, ENVIRONMENTAL PERSISTENCE, TOXICITY) |
|---|---|---|
| Carberyl | Insecticide - alkyl carbamate | Solid; solubility = 40 ppm at 30° C; nonpersistent; moderately toxic. |
| Carbofuran | Systemic insecticide | Crystalline solid; solubility = 250-700 ppm at 25° C; moderately persistent; toxic. |
| Disulfoton | Systemic insecticide - organo-phosphate | Liquid of low volatility; insoluble in water; nonpersistent; highly toxic. |
| Methyl parathion | Broad-spectrum nonsystemic insecticide - organo-phosphate | Low melting solid; low solubility in water; nonpersistent; highly toxic. |
| Toxaphene | Broad-spectrum insecticide - chlorinated hydrocarbon | Waxy solid; insoluble in water; nonpersistent if not applied directly into soil; moderate to high toxicity. |
| Alachlor | Selective herbicide | Low melting solid; solubility = 140 ppm; nonpersistent; moderately low toxicity. |
| Atrazine | Selective herbicide | Solid; nearly insoluble in water; nonpersistent; low toxicity. |
| 2,4-D | Selective herbicide | Solid; salts are water-soluble; acid and esters are insoluble; nonpersistent; moderately toxic. |
| Captan | Fungicide - chlorinated organo-sulfur compound | Solid; nearly insoluble in water; nonpersistent; low toxicity. |

[a] Midwest Research Institute, Production, Distribution, Use and Environmental Impact Potential of Selected Pesticides, 1974.

As is indicated by even the small sample of pesticides described in Table 18-1, the most toxic group of pesticides is insecticides. Neither herbicides nor fungicides prove to be highly toxic as tested in studies of mammalian toxicity. However, these categories also cover a number of hazardous materials. Federal actions have been taken toward several fungicides, including a class of fungicide called dithiocarbamates. This class of material accounted for approximately 50 percent of all the organic fungicides applied to crops in 1971.[4] Several classes of herbicides are also appraised as potentially hazardous. These are arsenicals, phenyl ureas, carbamates, triazines, and Treflan. One of the triazine herbicides, atrazine, is very widely used, and accounted for 25 percent of all herbicide used by farmers in 1971.[5]

The high level of mammalian toxicity of insecticides has been well established in laboratory tests. Much less is known about nonmammalian toxicity of these materials. Two subcategories of insecticides, chlorinated hydrocarbon insecticide and organic phosphate and carbamate insecticides, are of special interest because of their environmental persistence and toxicity. The chlorinated hydrocarbon group includes the banned chemicals DDT and aldrin/dieldrin. Residues from these pesticides proved to be very persistent in the environment. The use of organic phosphate and carbamate insecticides has increased as the use of the chlorinated hydrocarbon insecticides has declined. However, the biochemical action of these chemicals is based on the inhibition of cholinesterase, a vital body enzyme present in many species, making this group of materials highly toxic.[6]

The hazard of toxicity also exists with pesticide containers and with dilute pesticide solutions. Containers emptied in the field retain small quantities of pesticide residues. One applicator contacted in this study estimated that nearly a pint of chemical is left unused when a 5-gallon container is emptied. In more formal research, a study of pesticide residues performed in Illinois indicated that an average of 93 ml (2.3 oz) of pesticide remains in unrinsed containers.[7] Further details of the research are shown below in Table 18-2.

TABLE 18-2

PESTICIDE RESIDUES IN UNRINSED CONTAINERS[a]

| BRAND NAME | NUMBER OF USED CANS EXAMINED | AVERAGE RESIDUE PER CAN (ml) |
|---|---|---|
| Lasso | 345 | 45 |
| Belt | 139 | 221 |
| Eradicane | 129 | 120 |
| Treflan | 127 | 57 |
| Dyanap | 26 | 71 |
| Talban | 6 | 92 |
| Alfa-tox | 4 | 58 |
| Banvel K | 1 | 183 |
| DMA | 1 | 90 |
| Cythion 5E | 1 | 88 |
|  | 779 | 93 (2.3 oz) |

---

[a] Dr. J.K. Leasure, Final Report on Pesticide Containers, Illinois Institute for Environmental Quality, October 1978.

The study also included a controlled study of container rinsing. Several types of pesticide containers were emptied and rinsed in order to measure the pesticide residues present after each rinse. The water from the first rinse contained 2,000 to 10,000 ppm of the original pesticide material. Water from the second rinse contained from 150 to 1,200 ppm or less of material. The final rinse contained 120 ppm or less of material. It was concluded that triple-rinsed containers do not pose a disposal problem. The rinsing technique used involved adding water (equal to one-fourth of the container volume), shaking, and a 1-minute drain.

Dilute pesticide solutions from rinsing pesticide application vehicles involve a similar disposal problem. However, few data are available on the concentrations of pesticides from vehicle rinse operations.

Overall, it will be assumed for this study that all pesticide wastes (except triple-rinsed containers which are not considered hazardous under RCRA) are hazardous. This assumption is consistent with the general tenor of recommended disposal practices (such as those made under FIFRA).

## 18.2 Hazardous Waste Quantities

The waste materials under consideration here are of three types: (1) pesticide containers, with varying amounts of pesticide residues; (2) surplus pesticides; and (3) the disposal of dilute pesticide solutions generated as rinse water. The latter may include rinse water from containers or from application vehicles. Quantities are discussed in terms of average firm generation rates and then in aggregated national figures.

### 18.2.1 Model Firm Waste Quantities

The discussion of individual firm waste quantities will be oriented toward the likely waste quantities generated by an average-sized aerial application firm. The firm is presumed to own three aircraft. Each aircraft is flown 300 hours during a 7-month growing season. It is further estimated that 90,000 acres of cropland is covered during the season. The estimate of average hours flown and acreage covered is approximate, based on the research of Fred Clyne at Econ Inc.[8]

### 18.2.2 Used Pesticide Containers

Most pesticides are handled in 5-gallon containers. Other sizes used are 1-gallon, 55-gallon, and bulk (200- to 10,000-gallon) containers. In areas where there are large areas of a single crop, or where repeated application to a crop is needed, larger containers tend to be used. The relative proportions of these containers is discussed in Section 18.3 below.

A common rate of pesticide application is 1 quart per acre. This corresponds to the use of one 5-gallon can per 20 acres. Higher application rates (1/2 gallon per acre) increase the rate of used-container generation correspondingly. However, many pesticides are handled in paper bags, which reduces the number of containers substantially.

The model firm is assumed to cover 90,000 acres of crop per season. Of this, roughly 90 percent will involve pesticide application. Using the 1-quart/acre application rate, the applicator needs to handle 19,500 gallons of material.

However, it will be assumed that one-third of the material is handled in paper bags.[9] Liquid materials are assumed to come in 5-gallon cans and 55-gallon cans. A container mix of 1,500 5-gallon cans and 100 55-gallon cans appears representative for the area. The corresponding weight of containers for the season is 5.5 metric tons (6.05 tons).

A more definitive grasp on container quantities can be derived from a study of container rinsing and disposal in Illinois.[10] A survey of both ground and aerial applicators in Illinois indicated that the average number of 5-gallon pesticide containers used per firm was 885. A majority of firms used between 100 and 1,000 cans per year. The portion of the survey covering container quantities is provided in Table 18-3 below.

TABLE 18-3

CONTAINER ACCUMULATION BY CUSTOM APPLICATORS[a]

| NUMBER OF CONTAINERS[b] | NUMBER OF FIRMS REPORTING | TOTAL CANS | AVERAGE PER FIRM |
|---|---|---|---|
| 101-1,000 | 282 | 116,390 | 413 |
| 1,001-2,000 | 165 | 241,940 | 1,466 |
| 2,001-3,000 | 11 | 29,000 | 2,455 |
| 3,001-4,000 | 6 | 18,600 | 3,100 |
| 4,001-5,000 | 2 | 8,300 | 4,150 |
|  | 466 | 412,230 | 885 |

[a] J.K. Leasure, Report on Pesticide Container Disposal, prepared for Illinois EPA, October 1978.

[b] Only 5-gal containers.

### 18.2.3 Waste Pesticides

Some quantities of waste pesticide are generated on an irregular basis by custom application firms. One study, covering the disposal of waste pesticides in Iowa, indicated that 32 percent of the custom applicators responding did occasionally have unwanted pesticide materials. However, only 8 percent of the firms reported that they currently had unwanted pesticides. Thus, roughly one of twelve firms will have a waste pesticide disposal problem at a given time.

It is common practice in the industry for firms to have the necessary chemicals delivered at the field or airstrip by the farmer or by the pesticide dealer. This practice provides little opportunity for the applicator to generate excess pesticides.

However, occasional problems can occur. Some excess pesticides may be held at the end of the application season with the applicator unwilling or unable to store the material during the winter. Such materials may then be given away or disposed of in some fashion. Waste pesticides also occur when an application job is cancelled at the last minute, or when a solution is improperly mixed.

Estimation of these waste pesticide quantities is complicated by the irregular nature of the problem. For the model firm it will be assumed that no excess or waste pesticides are stored. However, three solutions of mixed pesticides must be disposed of during the season, due either to an error in preparation or last-minute job cancellations. Assuming the applicator capacity is 200 gallons, 2.3 $m^3$ (600 gallons) or 2.3 metric tons of material must be eliminated.

### 18.2.4 Dilute Pesticide Solutions

The custom applicator generates a dilute pesticide solution in the course of rinsing the application tank. If the applicator is also rinsing used containers, a rinsate solution is generated. The quantity of rinsate generated for a single aircraft will be discussed first.

Applicator tanks on aircraft are routinely rinsed when a new pesticide is to be used and at the end of the day. Rinsing when a pesticide is changed is necessary to avoid contamination of the new application spray. Rinsing at the end of the day is useful to limit corrosion of the application tank. In some areas, particularly in the East where a greater variety of crops is being sprayed, two rinses per day are frequently practiced. For the average aerial applicator, one rinse per day per plane is standard. Only a partial rinse may be used if the pesticide is not changed. As an average, only one rinse per day will be assumed for the model firm.

The quantity of rinse water needed varies with the size of the application tank. From one-eighth to one-fourth of tank capacity is common for rinse water volumes. Most application tanks for air equipment hold 200 to 250 gallons, although both larger and smaller sizes are used. Larger quantities of rinsate are needed in some cases to thoroughly remove acidic pesticide residues.[12]

For the model firm, it will be assumed that 90 gallons of rinse water are generated each day in rinsing three 200-gallon spray tanks. An additional allowance of 10 gallons is allowed for rinsing each plane exterior. To wash the plane completely, larger volumes would be needed.

However, the plane is rinsed less frequently than the spray tank. Monthly and annual volumes of rinsate are given below in Table 18-4.

## 18.3 Aggregate Waste Quantities

The estimates of total waste volume for the agricultural services industry are presented below. Data on waste quantities from the agricultural sector are limited. In some cases, the model firm will be the basis for estimation.

### 18.3.1 Used Container Quantities

Estimates of the number of containers used have been made for individual states by a variety of investigators. A number of the state surveys are provided in Table 18-5. These estimates cover the total number of containers used in each state, and thus include both farmers and custom

TABLE 18-4

MODEL FIRM RINSE WATER VOLUMES[a]

| PER MONTH | | PER YEAR[b] | |
|---|---|---|---|
| VOLUME | WEIGHT[c] | VOLUME | WEIGHT |
| 10.9 $m^3$<br>(2,880 gal) | 10.9 MT<br>(11.9 tons) | 76.5 $m^3$<br>(20,160 gal) | 76.5 MT<br>(84.2 tons) |

[a] ERCO estimate.

[b] Assumes a 7-month, 6-day-per-week season.

[c] A specific gravity of 1 is used.

## TABLE 18-5

## ESTIMATES OF THE TOTAL NUMBER OF PESTICIDE CONTAINERS USED[a]

| | STATE AND YEAR OF STUDY | | | | | | |
|---|---|---|---|---|---|---|---|
| | CA (70) | CA (72) | MS (73) | MS (74) | MT (71) | OR (72) | IL (78) |
| 55-gal metal drum | 8,000 | 8,000 | 49,100 | 90,900 | 5,900 | 15,000 | NA |
| 30-gal metal drum | 98,000 | 50,000 | 17,000 | 24,000 | | | NA |
| 5-gal container | 346,000 | 400,000 | 228,000 | 334,000 | 99,000 | 998,000 | 1,800,000 |
| 1-gal container | 172,000 | 800,000 | 775,900 | 620,000 | 4,000 | | NA |
| Paper bags | 3,239,000 | 5,600,000 | NA | NA | 21,000 | NA | NA |

---

[a] Arthur D. Little, Economic Analysis of Pesticide Disposal Methods, March 1977; and Dr. J.K. Leasure, Study of Pesticide Container Disposal in Illinois, in preparation, 1978.

applicators. As can be seen from Table 18-5, the estimates are quite varied. A portion of the variance is due to the different pesticide application requirements for crops in each state. In particular, cotton crops in Mississippi require large volumes of pesticide, much of which is distributed in 55-gallon drums. Thus, the large number of 55-gallon containers in that state is readily explained. The remaining variance cannot be explained simply in terms of the relative volumes of agricultural activity. For example, estimates of container use in Oregon, relative to that in California, appear quite high.

Since the early 1970's, when most of these estimates were made, bulk distribution of chemicals has become increasingly evident. With bulk distribution, a custom applicator or farmer receives pesticide material in tanks which can range in size from 200 to 10,000 gallons. The number of 5-gallon or 55-gallon containers is reduced accordingly. The question is then whether the movement into bulk containers has reduced or will soon reduce the volume of pesticide containers used. To date the use of bulk distribution has remained small. Only in the distribution of two high-volume pesticides, atrazine and Lasso, and in cotton-growing regions, has bulk distribution had an appreciable impact. For atrazine and Lasso, bulk distribution is estimated to account for from 10 to 20 percent of the total sales volume.[13] In the cotton-growing area, where bulk distribution has been used for several years, the market share is estimated at 25 percent. In the future, the use of bulk distribution will grow slowly. Major pesticide manufacturers are moving cautiously toward bulk containers but have met many difficulties. One executive mentioned that the logistics of bulk distribution are quite complicated and very region-specific.[14]

The estimated aggregated quantities of containers used by custom applicators are shown below in Table 18-6. No attempt was made to consider other container types such as 30-gallon containers, 1-gallon containers, and paper bags.

### 18.3.2 Waste Pesticides and Dilute Pesticide Solutions

The magnitude of the waste pesticide disposal problem is not well documented. A few states have instituted collection and disposal campaigns which produced large quantities of unwanted pesticides. One such program in Florida in 1970 gathered 93,000 pounds of pesticide for disposal. Other campaigns have uncovered significant inventories of DDT for disposal.[15] The greater portion of

TABLE 18-6

AGGREGATED QUANTITIES OF PESTICIDE CONTAINERS USED BY CUSTOM APPLICATORS

| CONTAINERS | TOTAL NUMBER | WEIGHT (MT)[a] |
|---|---|---|
| 55-gal | 800,000[b] | 17,000 |
| 30-gal | 4,700,000[c] | 11,000 |
| 5-gal | 75,000[d] | 800 |
| | | 28,000 |

[a] Weights of 20.9 kg (46 lbs), 11.3 kg (25 lbs), and 2.3 kg (5 lbs) were assumed for containers.

[b] Estimated from data in Table 18-5.

[c] Estimated from data in Table 18-5, and assumed to be used only in California.

[d] Estimated from data in Table 18-3, with an assumed population of 5,300 custom applicators.

the waste pesticide problem appears to rest with pesticide dealers. However, some custom applicators also sell material and could therefore have inventories of obsolete or banned chemicals. Pesticides which, when delivered to the applicator, are found to be spoiled can generally be returned to the dealer.

Waste pesticide solutions are generated in routine use. These wastes include pesticide solutions which are mixed by the applicator but which cannot be applied due to cancellation of the job or improper mixing. The estimated quantity of these solutions is shown below in Table 18-7. The estimates are based, in lieu of better information, on the model firm quantities.

The larger disposal problem is the disposal of the rinse water generated in rinsing applicator tanks. The estimated aggregate volume of this material is indicated below in Table 18-8. The combined volume of the waste pesticide volumes from Table 18-7 above is also included to give an overall estimate of the volumes generated by custom applicators.

Once again the basis for estimation is the model firm, a three-plane aerial applicator. Each plane is assumed to be rinsed once per day with 30 gallons of water. The aggregate quantity of rinse water was then arbitrarily increased 30 percent to account for the volume of operations in areas with growing seasons which are longer than the 7-month season of the model firm. Other ingredients in the estimation procedure are only rough approximations of average practice. These include the frequency of rinsing and the quantity of water per rinse.

## TABLE 18-7
## WASTE PESTICIDE SOLUTIONS

| ANNUAL QUANTITY FOR MODEL FIRM | | AGGREGATE QUANTITY[a] | |
|---|---|---|---|
| VOLUME | WEIGHT | VOLUME | WEIGHT |
| 2.3 $m^3$ (600 gal) | 2.3 MT | 10,000 $m^3$[b] | 10,000 MT |

[a] Based on a population of 5,300 custom applicators.

[b] Estimate is rounded off to the nearest 10,000.

## TABLE 18-8
## AGGREGATE VOLUME OF DILUTE PESTICIDE SOLUTIONS GENERATED BY CUSTOM APPLICATORS (1978)

| VOLUME OF RINSE WATER[a] | VOLUME OF WASTE SOLUTIONS | TOTAL VOLUME | TOTAL WEIGHT[b] |
|---|---|---|---|
| 530,000 $m^3$ | 10,000 $m^3$ | 540,000 $m^3$ | 540,000 MT |

[a] Based on the model firm and a population of 5,300 applicators. The estimate was then increased by 30% to account for firms operating in areas with longer growing seasons than the 7-mo season of the model firm.

[b] A specific gravity of 1 was used.

## 18.4 Number of Generators

As noted in Section 17.1, an estimated 5,300 firms are currently involved in the custom application of pesticides. This estimate includes 3,800 aerial applicators and 1,500 ground applicators. The estimate of ground applicators is quite literal in that it includes a number of firms primarily involved in fertilizer application. However, many of these firms appear to also use some herbicides, and will therefore be generating pesticide-related wastes.

## 18.5 Current Regulatory Framework

The Federal Insecticide, Fungicide, and Rodenticide Act required the development of disposal regulations by EPA for waste pesticides and pesticide containers. Recommended procedures for disposal have been published in the Federal Register (Vol. 39, No. 85). These procedures divide pesticide containers into three groups with specific disposal requirements for each group. The substance of the recommended practices is described briefly below.

Group I Containers. Combustible containers which contained organic or metallic-organic pesticides (except organic mercury, lead, cadmium, or arsenic compounds) should be disposed of in a pesticide incinerator or buried in a specially designated landfill; small quantities may be burned in open fields by the user when such open burning is allowed with due regard for protection of surface and subsurface waters.

Group II Containers. Noncombustible containers which formerly contained organic or metallo-organic pesticides (except organic mercury, lead, cadmium, or arsenic compounds) should be tripled-rinsed and recycled, returned to a drum reconditioner, or disposed in a sanitary landfill. Unrinsed containers must be disposed of in a specially designated landfill.

Group III Containers. Containers (combustible or noncombustible) which contained organic mercury, lead, cadmium, arsenic, or inorganic pesticides may be triple-rinsed and disposed in a sanitary landfill. Unrinsed containers should be encapsulated and buried in a specially designated landfill.

The extent to which these disposal practices have been incorporated into state regulations varies. Some states have adopted portions of the FIFRA recommendations although states are not required to do so. California has the most stringent regulations requiring that unrinsed containers and waste pesticides be disposed of in "Class I" landfill sites. A variety of employee safety regulations have also been instituted. Most notable of these is the stipulation that closed mixing systems be used in the preparation of pesticide solution. The closed mixing systems minimize employee contact with the materials.

Other states, including North Dakota, North Carolina, New Jersey, and Oklahoma, have established regulations paralleling the FIFRA regulations controlling disposal of pesticides and pesticide containers.[16] Several states are recommending and encouraging triple-rinsing of the containers if not actually requiring it. In Illinois, for example, triple-rinsed containers may be disposed of in municipal landfills, while a special permit is required for disposal of unrinsed containers. The state therefore encourages but does not require triple rinsing. Other midwestern states also include recommendations for triple rinsing the instruction material in certification classes for pesticide applicators. Discussions with custom applicators in a number of states indicated a general awareness of the triple-rinsing recommendations.

State regulations concerning disposal of dilute pesticide solutions are similarly varied and incomplete. States which control container disposal tend to also have regulations concerning the protection of ground and surface waters. However, no single control technology has been widely accepted. As a result, it is generally left up to the custom applicator to devise his own system for preventing environmental degradation.

In one survey of state regulations, it was determined that 15 states have no specific pesticide, pesticide solution, or pesticide container disposal regulations.[17] Several other states have regulations which require, in some general terms, disposal which will prevent environmental degradation.

## 18.6 Current Disposal Practices

Comprehensive surveys of disposal practices have not been conducted. In this section, such information as has been collected will be presented. In general, disposal practices are much below those which will be required under RCRA. Applicator practice is in line with the paucity of state regulations concerning disposal practices.

### 18.6.1 Container Rinsing and Disposal

A recent study of disposal practices for pesticide containers was performed in Illinois.[18] The principal thrust of the study was to determine the extent to which pesticide containers were being properly rinsed and disposed of by farmers and by custom applicators. Illinois encourages but does not require triple-rinsing of containers.[19] The properly rinsed containers may be disposed of at municipal landfills, but unrinsed containers require disposal at a few specially designated landfills. The farmer or applicator must also obtain an additional permit to dispose of the unrinsed containers.

The study involved both the analysis of the waste residue in discarded 5-gallon containers and a survey of farmers and custom applicators. The analysis showed that 17 percent of the drums examined had been rinsed, 34 percent had probably been rinsed, and 49 percent had probably not been rinsed. Furthermore, the survey of custom applicators indicated only a few were triple-rinsing the containers. The results of this portion of the study are shown in Table 18-9. Of the 466 custom applicators surveyed, only 18 percent said they were triple-rinsing the containers, although 43 percent stated that they were doing some rinsing. Rinsing practices for farmers were found to be significantly better, with 35 percent triple-rinsing.

Ultimate disposal practices were also investigated. Of the custom applicators, 72 percent reported taking the containers to a landfill, 14 percent to a private dump, and 23 percent for recycling. Multiple responses were received so that the total percentages add to more than 100 percent.

## TABLE 18-9

## DISPOSAL PRACTICES IN ILLINOIS - SURVEY OF CUSTOM APPLICATORS[a]

| NO. OF CANS HANDLED PER YEAR | NO. OF FIRMS REPORTING | FIRMS RINSING (%) | FIRMS TRIPLE RINSING (%) | CANS TRIPLE-RINSED (%) |
|---|---|---|---|---|
| 101-1,000 | 282 | 34 | 20 | 19 |
| 1,001-2,000 | 165 | 58 | 17 | 14 |
| 2,001-3,000 | 11 | 51 | 18 | 24 |
| 3,001-4,000 | 6 | 33 | 0 | 0 |
| 4,001-3,000 | 2 | 50 | 0 | 0 |
| Total | 466 | 43 | 18 | 15 |

[a] Leasure, J.K., Pesticide Container Disposal in Illinois, Illinois EPA, October 1978.

The typical custom applicator appears to accumulate empty unrinsed containers and then takes them to a regular landfill.

An earlier study of disposal practices (Iowa, 1972) also indicated that a majority of pesticide containers are taken to landfills. However, significant numbers were being burned or buried. (The study included paper bags.) The breakdown of disposal practices which applicators reported is provided in Table 18-10.

### 18.6.2 Pesticides and Pesticide Solutions

The study of disposal practices in Iowa (noted in the previous section) also covered disposal of leftover or unwanted pesticides. Results of this portion of the study are shown in Table 18-11. In terms of leftover or excess pesticides, disposal problems apeared to be relatively

## TABLE 18-10

## PESTICIDE CONTAINER DISPOSAL IN IOWA[a]

| METHOD | RESPONDENTS[b] (%) |
|---|---|
| Burn | 44 |
| Bury | 13 |
| To landfill | 57 |
| To dump | 24 |
| Incinerate | 0 |
| Leave in field | 5 |
| Return to dealer | 5 |
| Use for storing pesticides | 8 |
| Throw in trash | 6 |
| Recycle or take to cooperate | 3 |
| Store | 5 |

---

[a] Ryan, S.O., A Study of Pesticide Use, Storage and Disposal in Iowa, Ph.D. dissertation, Iowa State University (Ames), 1974.

[b] Allowed for multiple responses.

innocuous. Many applicators (44 percent) reported that they never had leftover material. A majority (60 percent) reported that the material was sprayed as intended. It appears probable that the second group substantially overlapped with the first. However, unwanted pesticides were frequently buried or landfilled, according to the same survey.

A study of disposal practices in Mississippi in 1970 indicated many dangerous disposal practices for unwanted pesticides. The survey results are reported in Table 18-12. Mississippi regulations have been upgraded considerably since 1970, and current disposal practices appear to be radically different from those indicated in the survey.[20]

## TABLE 18-11

## DISPOSAL PRACTICES IN IOWA - SURVEY OF APPLICATORS[a]

| METHOD OF DISPOSAL | LEFTOVER PESTICIDES | UNWANTED PESTICIDES |
|---|---|---|
| Burn | 2 | 7 |
| Bury | 9 | 44 |
| To landfill | 7 | 33 |
| To dump | 2 | 0 |
| Incinerate | - | - |
| Leave in field, ditch | 0 | - |
| Return to dealer | - | 41 |
| Use for storing pesticides, other | - | - |
| Throw in trash | 0 | 0 |
| Recycle or take to cooperage | - | -- |
| Store | 17 | 11 |
| Leave in equipment for next job | 20 | - |
| Give to someone who needs it | 5 | 19 |
| Spray as intended | 60 | 19 |
| Never have leftover | 44 | - |
| Pour on ground | 7 | - |
| Pour in drain | 3 | 0 |
| Special disposal system | 6 | 0 |

---

[a] Ryan, S.O., A Study of Pesticide Use, Storage and Disposal in Iowa, Ph.D. Dissertation, Iowa State University (Ames), 1974.

TABLE 18-12

DISPOSAL OF UNUSED PESTICIDES, MISSISSIPPI, 1970[a]

| METHOD | PERCENTAGE |
|---|---|
| Return to dealer (unopened) | 7.0 |
| Dump in city sewer system | 1.6 |
| Applied to soil surface | 15.6 |
| City dump | 11.0 |
| Sanitary landfill | 6.3 |
| Buried | 24.2 |
| Burned | 7.0 |
| Stored for possible future use | 27.3 |

[a] Mississippi State University, Study of Disposal Practices, 1970, as cited in Economic Analysis of Pesticide Disposal Methods, Arthur D. Little, March 1977.

Contacts with applicators in other states have shown that disposal practices are varied and irregular. When a pesticide solution is improperly mixed and is to be disposed, many applicators dump the solution into a hole for evaporation. Evaporation does provide volume reduction and some degradation. However, groundwater problems can occur.

The pesticide solutions generated from rinsing of the application tank represent a much larger waste disposal problem. The common disposal methods are listed below:

1. Uncontrolled runoff.
2. Collection and application to small land areas near the mixing site.
3. Collection in a settling pond, with contractor disposal of residues.

4. Collection in a settling pond, with eventual seepage into the soil.

5. Application to crops.

The percentage of applicators using each disposal method could not be reasonably estimated. Nevertheless, some general patterns in disposal practices can be discerned. First, the relatively uncontrolled disposal practices (1, 2, and 4 above) appear to be used by a clear majority of firms. This finding is consistent with the lack of state regulations and the absence of widely accepted control technologies for this waste stream.

Second, land crop application is an environmentally acceptable control strategy in most cases but its applicability is limited. Ground applicators can use this method with relative ease when rinsing in the field with a water supply available. Aerial applicators can spray the rinse water over cropland on their last run of the day. However, land application is not always feasible for either group. Ground applicators do not always have a water supply available when operating in the field. The nurse tanks (support vehicles used to carry material into the field to refill the application equipment) often carry no water. In combined fertilizer-herbicide applications, the nurse tank carries only liquid fertilizer and herbicide for mixing. Aerial applicators cannot spray the dilute rinse water when they are operating at a significant distance from their airport, and thus from their mixing site. With a ferry distance of 20 miles or more, which is common, the spraying of rinse water would be time-consuming and expensive.

## 18.7 Disposal Practices Required Under RCRA

Under RCRA, disposal practices for unrinsed containers and pesticide solutions will need to be upgraded. Custom applicators will have several choices concerning the method in which they comply with RCRA. The costs of representative disposal practices are provided below.

Used pesticide containers are considered a hazardous waste under RCRA (if the pesticides they contained are listed in the RCRA Section 3001 list) unless they have been triple-rinsed. In the cost analysis to follow it will be assumed that the custom applicator chooses not to rinse his containers. Thus all containers are assumed to require disposal as a hazardous waste. The cost of the time necessary for rinsing is substantial. The probable range appears to be from 3 to 5 minutes per 5-gallon container.[21] Unrinsed containers will need to be taken to a hazardous waste landfill. Triple-rinsed containers will be accepted for disposal at sanitary landfills.

Waste or dilute pesticide solutions (pesticide mix or rinse water) will also be classified as a hazardous waste. Land application of materials over cropland is acceptable but this disposal method will not be generally feasible. As a result, collection and disposal as a hazardous waste will be required. For waste pesticides, controlled incineration will be needed. A relatively new technology for disposal of this waste will be used as representative of likely control costs. The technology, called soil mounds (or soil pits in an alternative but similar formulation), involves collection of the waste solutions in a lined, soil basin. Through evaporation and degradation, the volume of waste is reduced. The soil in the basin is eventually removed for separate disposal.

Under RCRA, custom applicators may be classified as generators (Section 3002). Applicator firms will also be transporters (Section 3003) of hazardous wastes, assuming they transport their used containers to the secure landfill. Most firms currently take containers to landfills.[22]

### 18.8 Disposal Costs

The costs for container disposal, waste pesticide disposal, and dilute pesticide solution will be considered separately. Examples of disposal costs are given for the model firm. A description of the relevant administrative costs are also provided.

#### 18.8.1 Container Disposal Costs

The costs of disposing of unrinsed containers in a secure landfill are assumed to be $55/MT, based on cost estimates made by another EPA contractor.[23] Collection of the containers for disposal should not increase disposal costs. For aerial applicators, the site of mixing operations is sufficiently centralized (namely at one or at most three airports) such that containers are currently collected. Some applicators reported that planes were also fitted with bins for holding containers when chemicals were to be mixed at a remote site.

Ground applicators are more likely to leave containers in the field. However, most firms appear to routinely collect containers. For containers currently being left in the field, the additional collection costs are negligible. In most cases, a wire bin can be attached to the application rig or to the nurse truck to carry emptied cans back to the storage site.

The remote location of custom applicators may mandate that they deliver the unrinsed containers to the hazardous waste site. The cost of transporting the containers is a function of the distance to the disposal site, the amount hauled, and the driver's wages. Assuming that the truck travels at an average speed of 30 miles per hour, and that vehicle expenses are 12 cents per mile, the cost per pound of containers can be approximated by the equation:[24]

$$C = \left(0.12 + \frac{L}{30}\right) \frac{2M}{W}$$

Where L = driver's wage

M = distance to the site

W = weight of the containers

C = total cost/lb

For the case where L = \$11/hr, M = 100 miles, W = 2.2 tons (1 metric ton, equivalent to 450 5-gallon containers), the cost of transportation is 4.35 cents/lb.

Average current practice is to take containers to a local dump. If the secure landfill is a greater distance from the applicator's operation, then only incremental transportation costs constitute RCRA impacts. For the model firm, the incremental transportation cost is assumed to be 3 cents/lb.

### 18.8.2 Waste Pesticide Disposal Costs

Costs for disposal of waste pesticides vary according to the type of material. An average cost of incineration of \$80/MT will be used. This figure is derived from average incineration costs for pesticides derived by another EPA contractor.[25]

### 18.8.3 Rinse Water Disposal Costs

Costs for the control of rinse water from custom applicator operations will be based on work performed by another EPA contractor, SCS Engineers, with the assumptions to be explained below. The costs are for the soil mounds technology. The requisite capital and operation costs for this system are provided in Table 18-13. Operating costs are estimated at \$25.20/m$^3$ of rinse water.

The costs presented in Table 18-13 are for a complete, high-quality soil mounds system. Also, the expected volume of rinse water to be absorbed is greater than that of the model firm being used for analysis in this study (1.7 m$^3$ compared to 0.45 m$^3$ daily). It may be possible for firms to use systems which are smaller and less elaborate. A low-cost version of the soil mounds technology may soon be required in California. The systems being considered in California are expected to cost \$2,000 or less.

Components of the system shown in Table 18-13, which would not be used in a simpler system, include the pump distribution box and leach lines. Labor requirements for collecting water and putting it into the system are expected to be relatively minor. Gutters or sloped mixing areas can

## TABLE 18-13

## SOIL MOUNDS COST ESTIMATE ($)[a]

| | | |
|---|---|---|
| Basis for Calculations | | |
| Rinse water volume: | $1.7\ m^3$ (450 gal)/day<br>$385\ m^3$ (102,000 gal)/yr<br>225 operating days/yr | |
| Capital costs | | |
| Holding tank | | 1,750 |
| Pump | | 600 |
| Distribution box | | 50 |
| Pit, liner, mounding | | 7,500 |
| Leach lines | | 450 |
| Gravel, soil | | 50 |
| Roof | | 1,750 |
| Fencing | | 700 |
| Total | | 12,850[b] |
| Yearly operating costs | | |
| Monitoring | | 2,400 |
| Electricity | | 100 |
| Labor (250 hr @ $11/hr) | | 2,750 |
| Fixed charges (25% of capital) | | 3,212 |
| System cleanup and spent soil disposal | | 1,240 |
| Total | | 9,702 |
| Operating costs per $m^3$ | | 25.20 |
| Operating costs per gal | | 0.095 |

---

[a] SCS Engineers, Disposal of Dilute Pesticide Solutions - A State of the Art Report, Draft Report to EPA, October 1978.

[b] The breakdown of total costs into components presented here are approximations made by ERCO, pending release of the final report.

be used to capture rinse water and channel it into the soil mound. The absence of the pump will further reduce the labor requirements for maintenance of the system. Roofing over the mound is considered optional. However, it is necessary to prevent rainwater from flooding the system.

However, some questions remain concerning the efficacy of a simplified soil mounds system. Without a pump for distributing rinse water throughout the system, incoming rinse water will remain temporarily on top of the mound surface. Air emission problems may then occur as volatile organic materials are released into the atmosphere.

In light of the uncertainty about the efficacy of the simplified system, the original cost estimate will be used. For the model plant, it is assumed that the system can be scaled down to fit the smaller requirements of this firm. The operating cost per $m^3$ of rinsewater of \$25.20 from Table 18-13 will be used. For the model firm, total operating costs would equal \$1,900 per year.

For the worst-case firm, which is a single aircraft firm and generates a smaller volume of rinse water, disposal will be assumed to be 50 percent more expensive. A figure of \$38 per $m^3$ for disposal will be used.

### 18.8.4 Administrative Costs

The tally of administrative costs applicable to the agricultural services industry is shown in Table 18-14. Elements of RCRA Sections 3001, 3002, and 3003 are expected to apply. The Section 3003 regulations are included because it is assumed that the custom applicator will be

## TABLE 18-14

## ADMINISTRATIVE COSTS FOR AGRICULTURAL SERVICES[a]

| | SUPERVISOR ($25/hr) | OPTION A COST ($) | OPTION B COST ($) |
|---|---|---|---|
| Section 3001 | | | |
| 1. Documentation of waste inventory | 2 | 50 | 50 |
| Section 3002 (Generators) | | | |
| 1. ID code application | 1 | 25 | 25 |
| 2. Quarterly and annual reports | 1 | 25 | 25 |
| Option A | 12 | 300/yr | - |
| Option B | 6 | - | 150/yr |
| 3. Storage of manifests | - | 20/yr | 20/yr |
| 4. Manifest handling ($3/manifest, 12 trips/yr) | - | 36/yr | 36/yr |
| 5. System design for labeling, manifesting, reporting, and identification of TSDF | 16 | 400 | 400 |
| 6. Ongoing supervision | 8 | 200/yr | 200/yr |
| Section 3003 (Transporters) | | | |
| 1. Registration | - | 24 | 24 |
| 2. Record-keeping | - | 116/yr | 116/yr |
| 3. Marking ($24/truck) | - | 24 | 24 |
| Total costs (first year) | | 1,295 | 1,045 |
| Recurring annual costs[b] | | 672 | 522 |

[a] ERCO estimates.

[b] Recurring costs are denoted as $/yr entries.

transporting unrinsed pesticide containers to a hazardous waste disposal site.

The time allotted to many of the major tasks, such as system design tasks and supervision tasks, have been reduced below those for other industries. As for gasoline service stations, the small size of the average establishment simplifies organizational and administrative tasks. Also, the absence of clerical help is assumed not to be a hindrance in completing paperwork tasks.

The first-year costs as shown are used to measure RCRA cost impacts on the model firm. However, the worst-case firm is assumed to be a very small firm, i.e., one aircraft and two men. Some of the tasks specified, such as ongoing supervision, will be minimal in this case. Also, the time required for system design is likely to be reduced because the owner-operator need only establish procedures for himself and his assistant. However, no adjustments were made to the costs incurred by the worst-case firms due to the speculative nature of these reductions.

It is assumed that the soil mounds systems will not be considered treatment or storage facilities, and thus subject to RCRA Sections 3004 and 3005 regulations. If this assumption is incorrect then the cost of the soil mounds technology could rise dramatically. In particular, financial responsibility costs for these small systems, which have not been defined, may be quite high. Other aspects of the 3004 and 3005 regulations would also add substantially to the costs shown here. In particular, additional permitting and reporting requirements, daily inspections, training programs, and contingency plans would add a substantial cost burden.

## NOTES TO CHAPTER EIGHTEEN

1. U.S. Department of Agriculture, "Quantities of Pesticides Used by Farmers in 1971," Economic Research Service, Washington, D.C., 1974.

2. Midwest Research Institute, Production, Distribution, Use, and Environmental Impact Potential of Selected Pesticides, CEQ, March 1974.

3. Information provided by Joel Alpert, Soil Scientist of ERCO.

4. Trask, Harry W., "Farm Use of Pesticides and the Potential Impact of RCRA," Memorandum, Hazardous Waste Management Division, EPA, December 1977.

5. Trask, "Farm Use of Pesticides and the Potential Impact of RCRA."

6. Midwest Research Institute, Production, Distribution, Use, and Environmental Impact Potential of Selected Pesticides.

7. Leasure, J.K., Final Report on Pesticide Containers, Illinois Institute for Environmental Quality, October 1978.

8. Personal communication between John Eyraud of ERCO and Fred Clyne of Econ Inc., November 15, 1978.

9. ERCO estimates based on discussions with custom applicators. The amount of material handled in paper bags is highly variable among regions. The assumption that one-third of the material is handled in paper bags appears to be very conservative. The model firm has container quantities well above the average for the industry. See note 7.

10. Leasure, J.K., Final Report on Pesticide Containers.

11. Based on personal communications between aerial applicators and John Eyraud of ERCO.

12. Personal communication between Tom Schaub of Evergreen Helicopter, Redding, California, and John Eyraud of ERCO, November 8, 1978.

13. Based on personal communication between John Eyraud of ERCO and Mr. Perty of Dow Chemical, Midland, Michigan, and Dr. Hunterwill of Ciba-Geigy, November 17, 1978 and July 25, 1978.

14. Based on personal communication between John Eyraud of ERCO and Mr. Perty of Dow Chemical, November 10, 1978.

15. Arthur D. Little, Economic Analysis of Pesticide Disposal Methods, EPA, March 1977.

16. Information based on contacts with a number of custom applicators and information presented in the Arthur D. Little report referenced in Note 15. An exhaustive survey of states was not made.

17. Arthur D. Little, Economic Analysis of Pesticide Disposal Methods, EPA, March 1977.

18. Leasure, J.K., Final Report on Pesticide Containers.

19. Based on personal communication between John Eyraud of ERCO and A.G. Taylor of Illinois Institute for Environmental Protection, September 21, 1978.

20. Based on personal communication between John Eyraud of ERCO and Mabry Anderson of Hattiesburg, Mississippi, September 8, 1978.

21. The range of 3 to 5 minutes per container is based on a recommended drain time of 30 seconds per rinse.

22. Based on information in the study by Dr. J.K. Leasure and discussions with custom applicators.

23. Battelle Columbus Laboratories, Cost of Compliance with Hazardous Waste Management Regulations, EPA, May 1978.

24. Arthur D. Little, Economic Analysis of Pesticide Disposal Methods.

25. Battelle Columbus Laboratories, Cost of Compliance with Hazardous Waste Management Regulations, Table IV-8 and page IV-31. Based on personal communication between John Eyraud of ERCO and Brian Traynor of Rollins Environmental Services, current rates of incineration appear to be substantially higher than those reported in the Battelle report.

## CHAPTER NINETEEN

## ECONOMIC IMPACT ANALYSIS FOR AGRICULTURAL SERVICES

This chapter will follow the formula of other chapters in presenting the expected economic impacts. First, the technical and administrative costs of RCRA compliance are analyzed from the perspective of the model and worst-case firms. Prices and sales volume are assumed to remain constant in this analysis. The second section presents aggregate cost impacts. The final section covers the likely industry responses to regulation.

### 19.1 Model Firm Impacts

The costs of RCRA compliance are significant for both the model and worst-case plants under Option A. The RCRA compliance costs and estimated impacts on net income are shown in Table 19-1. For the model firm total compliance costs reduce estimated pretax net income by 24 percent. Technical compliance costs account for a 17 percent fall in net income and administrative costs account for the remaining 7 percent. For the worst-case firm, net income is estimated to fall 46 percent. Technical costs represent 24 percent of the decline and administrative costs the remaining 15 percent. Once again, these results are based on the assumption that the firms are unable to increase prices. As will be discussed below, there is probably some scope for price increases. The worst-case firm may have to absorb a portion of its above-average compliance costs.

**Preceding page blank**

## TABLE 19-1

## IMPACTS ON THE AGRICULTURAL SERVICES MODEL FIRMS (OPTION A)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales[b] | 202,500 | 67,500 |
| Cost of operations and expenses | 186,300 | 62,100 |
| Incremental RCRA Impacts | | |
| Technical disposal costs | 2,750 | 1,300 |
| Administrative costs[c] | 1,200 | 1,200 |
| Pretax net income | 12,250 | 2,900 |
| Pretax net income (before RCRA) | 16,200 | 5,400 |
| Decline in pretax net income | 24% | 46% |

[a] ERCO estimates.

[b] Does not include the sale of any pesticide or fertilizer materials.

[c] Represents estimated first-year administrative costs. Recurring year costs are $672.

Option B costs shown in Table 19-2 are approximately equal to Option A costs. The only modification is due to a slightly smaller reporting requirement under Option B. The change in reporting requirements is estimated to reduce administrative costs by $150 per firm. The decline in net income due to Option B is estimated at 23 percent and 44 percent for the model and worst-case firms.

TABLE 19-2

IMPACTS ON THE AGRICULTURAL SERVICES MODEL FIRMS (OPTION B)[a]

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales[b] | 202,500 | 67,500 |
| Cost of operations and expenses | 186,300 | 62,100 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 2,750 | 1,300 |
| Administrative costs[c] | 1,050 | 1,050 |
| Pretax net income | 12,400 | 3,050 |
| Pretax net income (before RCRA) | 16,200 | 5,400 |
| Decline in pretax net income | 23% | 44% |

[a] ERCO estimates.

[b] Does not include the sale of any pesticide or fertilizer materials.

[c] Represents estimated first-year administrative costs. Recurring year costs are $522.

The calculations are, of course, highly dependent upon the assumption of an 8 percent earnings rate on gross revenues. As discussed previously, no complete information on industry finances and specifically on profit margins is available. The modest 8 percent rate on earnings was used here because a number of firms stated that profit margins were under 10 percent. Many firms, however, are making 10 to 20 percent earnings on gross revenues and would feel reduced margins as a result.

Another crucial assumption affecting these results concerns the size of the system needed for disposal of rinse water. For the model and worst-case firms it was assumed that the cost of disposal is \$25.20 and \$38 per cubic meter of rinse water, respectively. These costs may need to be adjusted once more experience is gained with these systems.

Finally, as mentioned in the previous chapter, no provision has been made in the administrative costs for compliance with 3004 and 3005 regulations. That is, these firms were not classified as treatment, storage, or disposal facilities. If this assumption is changed, then financial responsibility costs and various administrative costs would need to be added. The costs of financial responsibility requirements for such small systems have not been examined by EPA contractors.

## 19.2 Aggregate Costs

The aggregate costs of regulation on the industry are shown in Table 19-3. Compliance costs are \$22.5 million and \$21.7 million for Options A and B. The costs represent slightly over 1 percent of total 1977 production value.[1]

## 19.3 Industry Impacts

The model and worst-case firm impacts shown for RCRA Options A and B indicate significant cost impacts. Net income for the firms is positive after RCRA but is significantly reduced. These reductions are large enough that some firms may choose to cease operations rather than absorb the regulatory impact. The factors affecting the willingness of firms to stay in business will be examined in this chapter. A brief summary of industry impacts is shown in Table 19-4.

### TABLE 19-3

### AGGREGATE COST IMPACTS ON THE AGRICULTURAL SERVICES INDUSTRY (1977 $MM)[a]

| | OPTION A | OPTION B |
|---|---|---|
| Costs | | |
| Technical | 16.2 | 16.2 |
| Administrative | 6.3 | 5.5 |
| Total | 22.5 | 21.7 |
| Estimated 1977 production value | 1,900 | 1,900 |
| Compliance as a percent of 1977 production value | 1.2% | 1.1% |

[a] ERCO estimates.

Prices increases would, of course, ameliorate the RCRA impacts. The custom applicator industry is quite competitive and firms facing greater than average cost increases may suffer. The small operators, as represented by worst-case impacts, probably cannot increase their prices to levels higher than large operators in the same area. However, small price increases are involved (2 to 3 percent) and little can be predicted about differences in the ability of firms to make small price changes.

The most likely candidates for ceasing operations are the small firms. As noted for the worst-case firm, these firms may face greater proportional reductions in net income. The size distribution of ground and aerial applicators is shown above in Table 17-6. It is significant that there are many small firms within each group. The small ground applicators, in particular, appear to do only limited seasonal business. RCRA regulations may cause them to close or, where possible, to handle only fertilizer sales. The latter would, however, mean that they could not provide "weed and feed" (herbicide and fertilizer mixes) which are an important part of the ground application business.

Several additional "nonquantifiable" factors make it appear more likely that some firms will close. First, large numbers of operators have started in business within the last 4 years; these new entrepreneurs are likely to have a lower level of commitment to their enterprise. (They are also more likely to have the standard problems of new businesses, and therefore "worst-case" profits.) The quality of this entrepreneurial talent is also occasionally suspect. As one applicator put it, "There are more pilots than businessmen in this industry." More importantly, the major capital items can be sold, often to other firms. The industry is somewhat unusual in that its assets are mobile and could be transferred with relative ease among firms. Thus, the liquidation of firm assets may represent a relatively small loss to operators.

TABLE 19-4

SUMMARY OF IMPACTS
ON THE AGRICULTURAL SERVICES INDUSTRY[a]

| | OPTION A | OPTION B |
|---|---|---|
| Number of generators | 5,300 | 5,300 |
| Plant closures | Probable | Probable |
| Job losses | Probable | Probable |
| U.S. production cutbacks | Unlikely | Unlikely |
| Price increases | Small | Small |
| U.S. demand reduction | Small | Small |
| Balance of payments effects | None | None |

[a] ERCO estimates.

Production cutbacks should not present a problem as other firms in the area pick up the extra business. Firms leaving the industry are most likely to be situated in areas where they are competing with a number of firms.

Price increases and, as a result, demand reductions should be small. No balance of payments effects are foreseen.

## NOTES TO CHAPTER NINETEEN

1. The estimated 1977 figure for total production value was based on an estimated revenue of 1.1 billion for aerial applicators alone in 1976 (provided by Harold Collins of the National Agricultural Aviation Association). The figure was increased by 12 percent to reflect industry growth and then increased by 60 percent to approximate the contribution of ground applicators. This estimate includes the cost of materials applied.

# PART VII

# METAL AND MINERAL DISTRIBUTIONS

# CHAPTER TWENTY

# HAZARDOUS WASTES IN THE METALS AND MINERALS DISTRIBUTION INDUSTRY

## 20.1 Introduction

The metals and minerals distribution industry was briefly examined in order to identify significant hazardous waste streams and potential RCRA impacts. The industry, or more properly, the disparate industries loosely grouped within the metals and minerals distribution classification, are of interest because of the possibility that small processing operations of one sort or another are generating hazardous waste streams undetected by previous EPA studies. Metal distribution centers, for example, may do a certain amount of processing, such as electroplating, and the volumes of the attendant waste streams are significant to any economic impact analysis of RCRA.

Metals service centers and offices (SIC 5051) and coal and other minerals and ores (SIC 5052) are the two subsets of wholesale trade that will be considered in this section. The SIC 5051 class includes those establishments primarily engaged in marketing ferrous and nonferrous metal semi-finished products. These establishments may operate with warehouses (metals service centers) or without warehouses (metals sales offices). SIC 5052 firms are primarily engaged in the wholesale distribution of coal, copper, iron, lead, and other metallic ores except precious ores, and crude nonmetallic minerals except crude petroleum.

**Preceding page blank**

Within each of these two industries there are a large number of firms that do not handle the materials being distributed. Metals sales offices (i.e., those firms without warehouses) do not actually handle any metallic goods. They act as agents between a manufacturer and a buyer, and arrange for a sale of goods directly between the two. Thus, they have no operations that have the potential for generating metallic or process wastes. Similarly in SIC 5052, coal and mineral ores wholesalers function as agents or brokers and are not involved in the physical handling or storage of coal or mineral ores. There is no solid waste of interest from these firms. However, because the distribution system may be affected by RCRA, these firms may be affected as well. Therefore, the distribution system in these industries will be examined with respect to possible RCRA impacts.

Because of differences between firms within SIC 5051 and SIC 5052, as well as firms within each category, the analysis here will examine the following sub-industries separately:

SIC 5051:
- steel and ferrous metals service centers
- mercury wholesalers
- other nonferrous metals wholesalers

SIC 5052:
- coal wholesalers
- metal and mineral ores wholesalers

## 20.2 SIC 5051: Steel and Ferrous Metals Service Centers

Steel service centers act as intermediary suppliers and processors of steel goods between the mills and the end users of the steel goods. Because smaller customers cannot buy in large enough quantities to get bulk discounts from the mills, nor can they always maintain expensive steel processing equipment, most small users of steel goods purchase through a service center. Larger users can obtain bulk discounts and most often deal directly with a mill. They too may use service centers when they need quick delivery of material to replenish their inventory or when they need specialized alloys of steel. In addition to providing inventories of steel goods, the service centers also will grind, cut to length, slit, sheave, saw cut, and plate burn the materials to the customers' specifications. Because of this, smaller steel users do not need to maintain such equipment at their own plants.

Service centers do not process their metal goods in any way other than cutting or sizing of the metal. Services such as galvanizing, electroplating, coating, etc., are done by independent firms not connected with steel service centers. In rare cases, the service center will also provide these operations. Contacts with a variety of service centers indicated that very few service centers provide electroplating, with one source estimating that 1 percent or less of service centers are engaged in this operation. The discussion of wastes will not cover these exceptional cases.

### 20.2.1 Steel Service Center Wastes

During normal cutting, shearing, and slicing operations, service centers generate certain quantities of scrap, and flame burning operations generate slag. Lubricating oil is also used in the system to prevent friction in the cutting operations and to carry away metal fines. Normal industry practice is to separate the scrap metal from the oil. The resulting scrap metal is included with the other scrap and slag for sale. The oil is recycled for reuse in the cutting processes. Once the scrap is collected, it is sold to a scrap dealer. Almost any kind of metal generated as scrap can be sold and recycled. Although the scrap has a value of only 10 to 15 percent of its original price, the amounts of scrap material generated can be significant.

The amount of scrap metal generated varies a great deal depending upon the particular service center. For example, based on contacts with firms in the industry, service centers that specialize in bar stock generate less than 1 percent scrap as a percentage of volume sold. Service centers that specialize in other types of work may generate 15 to 20 percent scrap. Standard service centers that deal with a wide range of steel products generate around 5 to 6 percent of their final product as scrap. Assuming a 5 percent industry-wide average, the total amount of steel and ferrous scrap generated by steel service centers in 1976 was 5 percent of 10.9 million metric tons shipped to steel service centers, or 545,000 metric tons of scrap.[1]

During normal operations, a small but undetermined amount of fines is generated. Most fines are captured during cutting by coolants and oil that circulate around the blade and entrain the particles. There are a small amount of fines and shavings that inevitably end up on the floor. Almost all service centers either sweep or vacuum these particles up and then dispose of them with other office refuse. Waste oil which can no longer be recycled is disposed of by sale or simple disposal. The quantities of waste oil could not be estimated, but they appear to be very small. In terms of the total quantities of waste oil, they are insignificant.

### 20.2.2 Waste Properties

The small portion of metal dust that is disposed of with regular refuse instead of as scrap consists of very small particles of the steel products themselves. These materials should not present a hazard when disposed of in a municipal landfill. There is some possibility that the metal fines could become incompletely soluble over time with the degree of solubility depending on the amount of surface exposed and the pH of the extraction solution. However, it is expected that these particles would pass the TEP test specified in RCRA (Option B) and not require treatment as a hazardous waste.

## 20.3 Mercury Distributors

Mercury and its compounds are acknowledged to be an extremely toxic group of metals. Because of this established toxicity, any wastes containing mercury or mercury compounds is likely to be considered a hazardous waste. Thus, the mercury distributors will be examined as a special class of metals distributors.

Mercury wholesalers receive mercury from refiners and distillers in prepackaged form. The wholesaler can resell the mercury as it is received, or he can repackage the mercury into smaller containers for low volume users. Whenever mercury is handled or repackaged, there is a chance for spillage, Any mercury that is spilled is immediately contaminated because of the high purity of mercury. However, recleaning is a fairly simple process, so the spilled mercury is collected and sent to a mercury cleaner/distiller who can restore it to its original purity. Due to the price of the mercury there are major economic incentives to recover any spilled mercury and have it reclaimed.

Significant regulatory incentives also exist to encourage the full collection of any waste mercury. Existing water pollution regulations provide for stiff fines for any source emitting more than very small quantities of mercury wastes. Contacts with mercury distributors bear out the likely hypothesis that mercury wastes for wholesalers are miniscule. The handling process does not generate any routine wastes; any nonroutine wastes are collected due to the economic and regulatory incentives mentioned.

Therefore, although any wastes that can be potentially generated from mercury wholesalers are undeniably toxic, existing EPA regulations and other factors force mercury wholesalers to limit their emissions far below the 100 kilogram per month RCRA limit. For this segment of SIC 5051, RCRA legislation will have no impact.

## 20.4 Other Primary Metals Wholesalers

Some service centers specialize in nonferrous metals such as copper, brass, zinc, tin, aluminum, etc., that are used as intermediate products by manufacturers.[2] The role the nonferrous metals service center plays is very similar to that of the steel service centers. They provide both a warehouse which shoulders the inventory burdens of smaller firms as well as providing cutting and shaping services.

The percentage of nonferrous materials purchased through metals service centers is somewhat higher than for steel and ferrous metals. In contrast to the 18 percent of industry sales for iron and steel products, 26 percent of aluminum and 21 percent of brass sales were made through metals service centers in 1976.[3] This reflects the fact that there are fewer large-scale industrial uses for nonferrous metals as opposed to ferrous metals.

Nonferrous metals service centers do not provide additional services other than warehousing or cutting metals to desired specifications. Any other processes are, as in the steel service center sub-industry, performed by other independent firms. Thus, the process wastes from these firms amount to leftover material, scrap metal, cuttings, and fines. Small fine particles and shavings are collected during cutting operations with coolants and lubricants, at which point they are separated, the coolants recycled, and the waste metals combined for sale with other scrap. As in the steel service center industry, economic incentives exist to collect and sell as much of the scrap material as possible. Any remaining fines which are swept up after operations are discarded along with normal refuse. The quantity of such waste is undetermined; no distributor attempted to maintain any records of the amount of dust and fine particles not collected for scrap.

### 20.4.1 Toxicity of Wastes

The only wastes that are available for impingement on the environment are those very small proportions of metal fines that are not collected for scrap and waste oils. Although some metals, such as zinc or copper, are included on the EPA's recommended list of priority pollutants, these metals in elemental form such as occur from metals service centers are sufficiently inert so as to cause no hazard when disposed of with normal refuse bound for a landfill.

## 20.5 Coal Wholesalers

Coal wholesalers act almost exclusively as agents or brokers for the transfer of coal. Because transportation and handling costs can amount to a significant portion of the delivered price of coal, a minimum of transfer and handling of the coal occurs from mine mouth to end user. Electric utilities (72 percent of the coal used in the United States in 1975), coke plants (15 percent), and other manufacturing and mining industries (11 percent) are the largest users of coal.[4] A small amount of coal is shipped to local retailers; as a rule, these firms receive their coal directly from the mine as well. The only point where intermediate stockpiling occurs is at shipping docks where coal is unloaded from barges or freighters for final transfer to its ultimate destination. This coal is almost always part of a shipment that has been contracted for by an end user; it can be the property of the dock owner or distributor, who then seeks customers for the coal.

At all stages of distribution, the coal is handled by someone other than a wholesaler. Wholesalers do not maintain loading or unloading facilities nor do they maintain any stockpiles of coal. Therefore, the wholesalers do not generate any wastes. The wastes are generated at the mine or at the loading and unloading points, all of which fall under the responsibility of other industries. However, the basic distribution path will be examined to identify the sources and nature of wastes from coal distribution.

### 20.5.1 Waste Characteristics

There are four main points along the distribution path for coal that can result in wastes being generated:

1. Loading coal at the mines onto trucks or rail for transport.

2. Wind erosion of coal during transport.

3. Transfer of coal between different methods of transportation.

4. Wind erosion and runoff from precipitation while coal is in a storage pile.

Only with coal pile runoff are there any wastes other than coal dust. Coal pile runoff takes the form of coal and other particles leached out of the coal pile by rainwater or melting snow. Iron sulfides in the coal (particularly pyrite [$FeS_2$]), when leached out of the naturally reducing state of the coal pile, oxidize when exposed to oxygen and water. The sulfide is initially oxidized to ferrous iron ($Fe^{+2}$). The ferrous iron is ultimately oxidized to ferric iron ($Fe^{+3}$). At normal pH range (6 to 8) ferric iron hydrolizes forming acid and an insoluble, hydrated ferric oxide, which occurs as a gelatinous floc (yellow boy) and precipitates or adsorbs onto surfaces over which it flows.[5] This floc, although not toxic in itself, can coat organisms and gills of fish causing them to suffocate. The acid that is produced (mild $H_2SO_4$) can create an environmental problem as well. Additionally, coal dust itself may be carried away with the runoff. Because of the tightly linked molecules in the coal, however, any potentially hazardous constituents within the coal are difficult to liberate from the coal and create only very minor hazards. Other trace metals may also be in the coal and can be leached out of the pile along with coal particles and the iron sulfides. The concentrations of these particles vary with the particular coal, but concentrations within the runoff can be high enough to be considered potentially hazardous. Further discussion of coal pile runoff is provided in Chapter Three.

### 20.5.2 Regulatory Setting

Pollution from coal pile runoff is currently under the jurisdiction of the Clean Water Act (as amended). If the runoff is collected, a permit from the National Pollution Discharge Elimination System (NPDES) is required, since the pile is considered a point source. If the runoff is not collected, there is no current statute that dictates recovery of the runoff unless it can be shown that there is an environmental problem. Collection and control of the waste would be required under RCRA.

All the handling steps described above have the potential to generate fugitive dust emissions. Loading coal at the mine onto transportation, loading and unloading at an intermediate transfer point, and unloading at the end-use point are all operations that face EPA regulations for fugitive dust emissions. The responsibility for the dust control rests with the particular party actually handling the coal. Thus, once the coal leaves the mine, the mine owner has no responsibility for the emissions, and fugitive dust emissions are not the concern of the end user until the coal is unloaded at the plant. While in transit, there are no existing regulations that limit dust control because of the extremely difficult problem of monitoring emissions from the carriers.

## 20.6 Metals and Mineral Ores Wholesalers

The minerals in this class are primarily used as process inputs to make refined semifinished minerals or metals. The refining or smelting processes are capital intensive and exhibit significant economies of scale. For this reason, a few large firms exist that process almost all of the mineral ores. Thus, raw ores go in large shipments directly from the mine to the refiner or smelter. The distributor plays the role of an agent that arranges the transportation and does not physically handle or process the ores. No data detailing the exact percentage of ores shipped directly from the mine to the users were found; however, contacts with numerous ore distributors indicated that the percentage is indeed quite high, with no firms that were contacted maintaining any stockpile of material.

Stockpiles of ores are maintained by the mines, refiners and smelters, and at docks awaiting transfer and shipment. Any wastes from these piles, which can include runoff, handling wastes, and wind erosion, are the responsibility of the business entity that is loading, unloading, or storing the material. Thus, the wholesaler, who is acting only as an agent or broker, does not generate any solid wastes, nor is he responsible for their control.

As is the case with coal, wastes are generated via runoff and erosion from the transfer and storage of the ore piles. Depending on the ore, the wastes will contain various concentrations of base metals, inorganic and organic material, along with the basic ore itself. Runoff can produce leaching and acidity from some storage piles which result in environmental problems.

Thus, the metals and minerals wholesalers are in a similar position as the coal wholesalers. They act as brokers for a raw material, yet they never physically handle it. Controlled runoff is covered by water pollution regulations. Uncontrolled runoff may, however, be classified as a hazardous waste and require treatment under RCRA. These impacts would affect the distributors indirectly through impacts on ore mining industries or user industries.

## 20.7 Conclusions

Several of the operations examined generate wastes which may be classified as hazardous under RCRA. In particular, coal and ore pile runoff may be generated in sufficient quantities to classify firms as generators. Such wastes would generally not be the responsibility of the distributors, but of the mining industry or user industries. Therefore, no significant impacts on distributors are foreseen.

# NOTES TO CHAPTER TWENTY

1. Metal Distribution, 1978, p. 16.

2. Lead is rarely handled by service centers. Almost all lead goes directly from smelter or refiner to end or intermediate user.

3. Metal Distribution, 1978, p. 17.

4. U.S. Department of the Interior, Bureau of Mines, 1975, Minerals Yearbook, Volume I, p. 444.

5. Martin, H. and W.R. Mills, Jr., Water Pollution Caused by Inactive Ore and Mineral Mines, Toups Corporation, Santa Ana, California for EPA, Contract No. 68-03-2212 (1976).

# PART VIII

## REGULATORY IMPACTS UNDER RCRA OPTION C

Preceding page blank

## CHAPTER TWENTY-ONE

## RCRA IMPACTS UNDER OPTION C

After the production of the preceding chapters of this report, an analysis was performed of the impacts of a third regulatory option less stringent than either Option A or Option B. The goal of Option C is to reduce the overall economic impact on generators by either exempting them from regulatory compliance or limiting the costs of compliance, both technical and administrative. The option is, of course, accompanied by a lesser degree of environmental protection.

Table 21-1 presents the alterations to Option B that uniquely define Option C. Of particular note on this table are points 2, 3, and 5. Point 2 specifically eliminates the electric utility industry from any economic impact due to RCRA regulations. Point 3 proceeds to effectively eliminate 90 percent of all gasoline service stations and 95 percent of all automotive repair shops, as well as 25 percent of all chemical warehouses, from impact because the smallest of these facilities will not generate the requisite waste volumes to force them into regulatory compliance. Point 5, in conjunction with point 3, serves to exclude the agricultural services industry from impact.

For the remaining segments - the pulp and paper and the drum reconditioning industries - compliance costs are reduced, further lessening the impacts of Options A and B. The metal and mineral distribution industry, which

**Preceding page blank**

## TABLE 21-1

## LESSER DEGREE OF PUBLIC HEALTH AND ENVIRONMENTAL PROTECTION

### 3001 MODIFICATIONS (SUBPART A)[a]

1. Eliminate the characteristic for toxic wastes (250.13[4]).[a]
    - Eliminate the listed wastes whose listing is based solely on the toxicity characteristic (250.14).[a]
2. Exclude the following wastes from identification as hazardous wastes under Section 3001: cement kiln dust wastes, utility wastes, phosphate rock mining and processing wastes, uranium mining/milling wastes, and oil drilling mud/brines (250.14[a][2][ii]).[a,b]

### 3002 MODIFICATIONS (SUBPART B)[a]

3. Increase the generator limit from 100 kilograms per month to 1000 kilograms per month (250.21[6]).[a]
4. Increase the length of the permit exclusion for generators who temporarily store hazardous waste prior to off-site disposal from 90 days to 1 year (250.61[dd]).[a]
5. Add exclusion that pesticide applicators must comply with the Section 3002 requirements only for the treatment, storage and disposal of waste automotive oil.[b]
6. For off-site shipments of hazardous wastes by generators, replace the Section 3002 manifest requirements with a new manifest requirement that all such shipments (interstate and intrastate) must be accompanied by shipping paper/bill of lading which designates delivery to a permitted storage, treatment, or disposal facility and which meets the requirements of the DOT Hazardous Materials Regulations (250.21[3] and 250.22).[a]
    - For example, spill information need not be provided on the shipping paper/bill of lading,

---

[a] Section in Appendix B that is being changed by this modification.

[b] No equivalent regulation appears in Appendix B.

TABLE 21-1 (CONT.)

and the shipping paper/bill of lading need only be signed as required under the DOT Hazardous Materials Regulations (i.e., must be signed only by the generator shipping the wastes).

7. Replace requirement for recordkeeping of manifest copy with a requirement for recordkeeping of shipping paper/bill of lading (250.24).[a]

   - Decrease recordkeeping time for shipping paper/bill of lading used in place of manifest from 3 years to 1 year.

8. Eliminate the reporting of shipping paper/bill of lading not received at designated facility (250.23[a][2]).[a]

3003 MODIFICATIONS (SUBPART C)[a]

9. Replace the Section 3002 manifest requirements with a requirement that all shipments (interstate and intrastate) must be accompanied by shipping paper/bill of lading which designates delivery to a permitted storage, treatment, or disposal facility and which meets the requirements of the DOT Hazardous Materials Regulations (250.21[3] and 250.22).[a]

   - Eliminate need for signatures on shipping paper/bill of lading, except as required under the DOT Hazardous Materials Regulations (i.e., must be signed only by the generator shipping the wastes).

10. Replace requirement for recordkeeping of manifest with a requirement for recordkeeping of shipping paper/bill of lading (250.33).[a]

    - Decrease recordkeeping time for shipping paper/bill of lading form 3 years to 1 year, except where DOT Hazardous Materials Regulations specify retention times longer than 1 year.

11. Eliminate special emergency spill regulations (250.37).[a]

---

[a] Section in Appendix B that is being changed by this modification.

## TABLE 21-1 (CONT.)

- Eliminate requirements for the transporter to notify appropriate officials in the case of a spill and to file a report on the spill.
- Eliminate requirement for transporter to clean up spill or to take other action required to insure the spill no longer presents a hazard to human health or the environment.

12. Eliminate requirement that if a transporter consolidates shipments of hazardous wastes that do not require a manifest, the entire shipment must be delivered to a permitted facility (250.30[a]).[a]

### 3004 MODIFICATIONS (SUBPART D)[a]

13. Eliminate special waste standards for cement kiln dust wastes, utility wastes, phosphate rock mining and processing wastes, uranium mining/milling wastes, and oil drilling muds/brines (250.46).[a]
    - Exclude these wastes from compliance with Section 3004 regulations.
14. Change the application of the threshold limit value for air contaminants from non-point emission sources (250.42-3[b]).[a]
    - The threshold limit value is to be applied as a time-weighted average for a 24-hour day rather than as a time-weighted average for an 8-hour day and 40-hour week.
15. Decrease the minimum distance active portions of facilities must be located from the facility's property line from 200 feet to 100 feet (250.43-1[h]).[a]
16. Decrease the minimum distance surface impoundments, active portions of landfills, and treated areas of landfarms must be located from any functioning public or private water supply or livestock water supply from

---

[a] Section in Appendix B that is being changed by this modification.

TABLE 2-21 (CONT.)

150 meters (500 feet) to 75 meters (250 feet) (250.45-2[a][3], 250.45-3[a][3], and 250.45-5[c][3]).[a]

17. Decrease the financial responsibility required of owners/operators of treatment, storage, or disposal facilities during site operation from a minimum of $5 million to a minimum of $2 million (250.43-2[b]).[a]

18. Decrease the time during which the owner/operator of a facility is to provide post close-out care from a period not to exceed 20 years from close-out to a period not to exceed 10 years from close-out (250.43-8[k][1]).[a]

    - The annual cash payment into the trust fund for post closure monitoring and maintenance is to be adjusted based upon this 10-year period (250.43-2[a][2]).[a]

19. For incineration, reduce the destruction efficiency from 99.99% to 99.9%, the combustion efficiency from 99.9% to 99%, and halogen removal from exhaust gases from 99% to 90% (250.45-1[b], 250.45-1[d], and 250.45-1[h]).[a]

20. For all landfills and surface impoundments, decrease the required permeability of the soil liner and of the final cover from less than or equal to 1 x $10^{-7}$ cm/sec to less than or equal to 1 x $10^{-6}$ cm/sec (250.45-2[b][10], 250.45-2[b][12][ii], 250.45-2[b][12][v], 250.45-2[c][1], 250.45-3[c][2], and 250.45[c][9]).[a]

21. Limit to groundwaters that are underground drinking water sources the requirement that all facilities, except landfarms, that have the potential to discharge to groundwater must be monitored to detect any discharge (250.43-9).[a]

    - There does not have to be monitoring of potential discharge to groundwaters which are non-underground drinking water sources.

22. For those facilities for which there is to be groundwater and leachate monitoring, eliminate the quarterly monitoring and minimum analysis of samples from both the leachate

---

[a] Section in Appendix B that is being changed by this modification.

TABLE 21-1 (CONT.)

---

detection system and the groundwater (250.43-9[b][4] and 250.43-9[b][5]).[a]

- Eliminate the quarterly reporting of this monitoring data (250.43-9[d][1]).[a]
- Retain annual monitoring and comprehensive analysis (250.43-9[c][4] and 250.43-9[c][5).[a]

23. Eliminate the restriction on the maximum vapor pressure of wastes that may be treated, disposed, or stored as indicated below (250.44-1[a][1], 250.45-2[b][5][iii], 250.45-3[b][1][v], 250.45-4[2][e], and 250.45-5[1][ii]).[a]
    - Wastes with a vapor pressure greater than 78 mm of Hg at 25 C may be disposed in landfills, placed in surface impoundments or basins, landfarmed, or put in storage tanks vented directly to the atmosphere.
24. Increase the time requirement for training of personnel from 6 months to 1 year (250.43-5[a]).
25. Eliminate the regulation of commercial products made from hazardous wastes (250.45-7).[a]
    - Such commercial products are not to be considered hazardus wastes.
26. Replace requirements for recordkeeping of manifest copy with a requirement for recordkeeping of shipping paper/bill of lading (250.43-6[a][2]).[a]
    - Decrease recordkeeping time for shipping paper/bill of lading used in lieu of manifest from 3 years to 1 year (250.43-6[a][2]).[a]
27. Eliminate need for signatures on shipping paper/bill of lading, except as required under the DOT Hazardous Materials Regulations (250.43-6[a][1][a]).[a]

---

[a] Section in Appendix B that is being changed by this modification.

TABLE 2-21 (CONT.)

---

3005 MODIFICATIONS (SUBPART E)[a]

---

28. Increase the length of the permit exclusion for generators who temporarily store hazardous wastes prior to off-site disposal from 90 days to one year (250.61[dd]).[a]

29. Eliminate the need for publically owned treatment facilities, qualified hospital-medical care facilities, and ocean dumping barges or vessels to apply for a special permit (250.62-7[b], 250.62-8[b], and 250.62-9[b]).[a]

    - Such facilities are automatically granted the special permits.

---

3006 MODIFICATIONS (SUBPART F)[a]

---

30. Eliminate restrictions on granting of full or partial authorization to states with more stringent standards (250.72[a][ii] and 250.72[b][1]).

31. Eliminate all restrictions on granting of interim authorization, except for the Memorandum of Understanding (250.73).[a]

    - All states desiring interim authorization are to be granted it, providing that they have a Memorandum of Understanding.

---

3010 MODIFICATIONS (SUBPART G)[a]

---

32. Retail generators need not notify (250.820[a]).[a]

---

[a] Section in Appendix B that is being changed by this modification.

faced negligible impact under either Option A or B, will remain free of significant impact under Option C.

Table 21-2 displays a summary of the aggregate impacts on the selected industries of Option C. The table shows that Option C will affect almost 21,000 plants and, in the aggregate, cost under $110 million annually.

The remainder of this chapter details the impacts of Option C on an industry-by-industry basis.

## 21.1 Electric Utilities

The electric utility industry is specifically exempted from RCRA regulations under Option C. Accordingly, there will be no costs or attendant impacts for the industry under this regulatory option.

## 21.2 Pulp and Paper Manufacturers

The cost impacts of RCRA regulations will be reduced under Option C. While the number of generators will not change between Option B and Option C, there will be a significant reduction in administrative costs for onsite disposers under Option C. Additionally, there will be a reduction in the technical disposal cost to onsite disposers, due to slightly less stringent design criteria. The effect of the last point could not be estimated for this study.

Table 21-3 displays the impact of Option C regulations on the model plant. As can be seen from the table, the decline in that income due to regulations is reduced from

## TABLE 21-2

## AGGREGATE IMPACTS OF OPTION C ($000)[a]

| INDUSTRY | NUMBER OF GENERATORS AFFECTED | TECHNICAL DISPOSAL COST | FIRST-YEAR ADMINIS-TRATIVE COST | TOTAL FIRST-YEAR COST | FIRST-YEAR COST AS PERCENTAGE OF ANNUAL SALES | TOTAL SUC-CEEDING YEAR COST |
|---|---|---|---|---|---|---|
| Electric utilities | 0 | - | - | - | - | - |
| Pulp and paper | 561 | 68,600 | 11,800[b] | 80,400[b] | 0.2 | 80,400 |
| Gasoline service stations and automotive repair shops | 19,860 | 19,400 | 1,500 | 20,900 | <0.05 | 19,800 |
| Drum reconditioners | 190 | 7,100 | 400 | 7,500 | 1.2 | 7,300 |
| Chemical warehousing | 270 | 522 | 540 | 1,062 | <0.05 | 693 |
| Agricultural services | 0 | - | - | - | - | - |
| Metal and mineral distributors | 0 | - | - | - | - | - |
| Total | 20,881 | 95,622 | 14,240 | 109,862 | NA[c] | 108,193 |

[a] ERCO estimates.

[b] Costs shown is average annualized cost.

[c] NA = not applicable.

Option B to Option C for both the model and worst-case firms. The analysis in Table 21-3 fails to account for potentially reduced technical disposal costs resulting from a more lenient design specification for permeability.

Aggregate industry impact is displayed in Table 21-4. This table shows that the reduced costs of on-site disposal under Option C reduce the cost of RCRA regulations by about $6 million, but this reduction is barely significant vis-a-vis industry sales.

The comparison of the administrative costs of Option C with Options A and B is portrayed in Table 21-5 for onsite disposers and Table 21-6 for offsite disposers. The table shows that onsite disposers will force annualized administrative costs of less than 63 percent of those for option B and less than 40 percent of those for Option A. This change is due primarily to the lessening of the requirement for financial responsibility. Offsite disposers will face a negligible reduction in administrative costs.

## 21.3 Gasoline Service Stations and Automotive Repair Shops

The impacts of RCRA on service stations and repair shops will be dramatically reduced under Option C. Because of the increase in the minimum hazardous waste generation requirement (from 100 kg/month to 1000 kg/month) only 10 percent of gasoline service stations and 5 percent of automotive repair shops will be affected by Option C regulations. Option C will have the same administrative costs as encountered in Option B for these two segments because of the unique treatment of waste oil under both Options B and C. Unit treatment costs will also remain the same; however, because

## TABLE 21-3

## IMPACTS ON PULP AND PAPER MODEL PLANTS (OPTION C) ($000)[a]

| | MODEL PLANT | WORST-CASE PLANT |
|---|---|---|
| Sales | 70,900 | 44,500 |
| Cost of operations | 52,600 | 27,200 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 245 | 431 |
| Administrative costs | 63 | 63 |
| Pretax net income | 17,992 | 16,806 |
| Pretax net income (before RCRA) | 18,300 | 17,300 |
| Decline in pretax net income under Option C | 1.7% | 2.9% |
| Decline in pretax net income under Option B | 1.9% | 3.1% |

[a] ERCO estimates.

## TABLE 21-4

## AGGREGATE COST OF COMPLIANCE FOR THE PULP AND PAPER INDUSTRY ($000)[a]

| | OPTION A | OPTION B | OPTION C |
|---|---|---|---|
| Number of generators | 561 | 561 | 561 |
| Technical | 287,400 | 68,600 | 68,600 |
| Administrative | 66,600 | 17,900 | 11,800 |
| Total | 354,000 | 86,500 | 80,400 |
| 1977 production value | 40,200,000 | 40,200,000 | 40,200,000 |
| Costs as a percent of production value | 0.88% | 0.22% | 0.20% |

[a] ERCO estimates.

## TABLE 21-5

## ADMINISTRATIVE COSTS OF COMPLIANCE WITH RCRA FOR ON-SITE DISPOSAL OF PULP AND PAPER WASTES[a]

| ADMINISTRATIVE TASK | COSTS ($)[b] | | | | | |
|---|---|---|---|---|---|---|
| | OPTION A | | OPTION B | | OPTION C | |
| Section 3001 | | | | | | |
| Waste analysis ($2,300/test, 5 tests/yr for 3-5 waste stream) | 34,500 | (34,500) | 34,500 | (34,500) | 34,500 | (34,500) |
| Documentation of waste analysis | 240 | | 240 | | 240 | |
| Supervision of testing, documentation | 50 | (50) | | (50) | 50 | (50) |
| Section 3002 | | | | | | |
| Application for I.D. Code | 32 | | 32 | | 32 | |
| Section 3004 | | | | | | |
| Surface water monitoring[c] | 21,000 | (21,000) | 21,000 | (21,000) | | |
| Groundwater monitoring | 6,200 | (6,200) | 6,200 | (6,200) | 6,200 | (6,200) |
| Notification of disposal operations | 32 | | 32 | | 32 | |
| Reporting of disposal data | 1,136 | (1,136) | 1,136 | (1,136) | 1,136 | (1,136) |
| Reporting of monitoring data | 260 | (260) | 260 | (260) | 80 | (80) |
| Develop contingency plan | 493 | | 493 | | 493 | |
| Systems design for proper facility operation | 2,142 | | 2,142 | | 2,142 | |
| Daily inspections | 20,075 | (20,075) | 10,040 | (10,040) | 10,040 | (10,040) |
| Updating of procedures | 811 | (811) | 811 | (811) | 811 | (811) |
| Section 3005 | | | | | | |
| Develop description of site | 42,600 | | 11,000 | | 11,000 | |
| Design financial requirement plan | 1,340 | | 1,340 | | 1,340 | |
| Assess and redesign facility | 1,730 | | 1,730 | | 1,730 | |
| Understanding of permit (legal aid) | 1,790 | | 1,790 | | 1,790 | |
| Training program | 13,750 | (4,500) | 2,000 | (1,000) | 2,000[d] | (1,000) |
| Contingency plan costs | 4,000 | | 4,000 | | 4,000 | |
| Continuing supervision | 1,000 | (1,000) | 1,000 | (1,000) | 1,000 | (1,000) |
| Financial responsibility costs | 63,000 | (63,000) | 21,000 | (21,000) | 4,200 | (4,200) |
| Total | 216,181 | (152,532) | 120,796 | (96,997) | 82,816 | (59,017) |
| Annualized costs | 162,888 | | 100,869 | | 62,889 | |

[a] ERCO estimates.

[b] Figures are for first-year costs. Recurring annual costs are in parentheses. Annualized costs are the sum of recurring costs and 16.27% of nonrecurring costs.

[c] Assumes $350/sample with testing at 6 sites, 10 times per year.

[d] Although the training period is extended from 6 months to 1 year, it is estimated in ADL, January 1979 that training costs will be the same for Options B and C.

## TABLE 21-6

## ADMINISTRATIVE COSTS OF COMPLIANCE WITH RCRA FOR OFF-SITE DISPOSAL OF PULP AND PAPER WASTES [a]

| | COSTS ($)[b] | | | | | |
|---|---|---|---|---|---|---|
| | OPTION A COSTS ($/yr) | | OPTION B COSTS ($/YR) | | OPTION C COSTS ($/YR) | |
| ADMINISTRATIVE TASK | FIRST YEAR | RECURRING | FIRST YEAR | RECURRING | FIRST YEAR | RECURRING |
| Section 3001 waste analysis | 34,500 | 34,500 | 34,500 | 34,500 | 34,500 | 34,500 |
| Documentation of wastes | 240 | | 240 | | 240 | |
| Supervision of documentation | 50 | 50 | 50 | 50 | 50 | 50 |
| Section 3002 aplication for I.D. code | 32 | | 32 | | 32 | |
| Reporting of generation | 586 | 586 | 242 | 242 | 242 | 242 |
| Storage of manifests | 20 | 20 | 20 | 20 | 5 | 5 |
| Manifests ($3/manifest, 1/wk) | 156 | 156 | 156 | 156 | - | |
| System design for handling, disposal | 993 | 993 | 993 | 993 | 993 | 993 |
| Supervision of system design | 300 | 300 | 300 | 300 | 300 | 300 |
| Ongoing supervision | 600 | 600 | 600 | 600 | 400 | 400 |
| Maintenance, refinement of procedures | 214 | 214 | 214 | 214 | 214 | 214 |
| Total | 37,491 | 37,219 | 37,347 | 37,075 | 36,976 | 36,704 |
| Annualized costs | 37,263 | | 37,119 | | 36,748 | |

[a] ERCO estimates.

[b] Figures are for first year costs. Recurring annual costs are in parentheses. Annualized costs are the sum of recurring costs and 16.27% of nonrecurring costs.

only large facilities will be subject to regulation under Option C, technical costs per plant will increase. Firms exempted by the 1000 kg/month limitation may incur some administrative cost to determine their exemption, but these costs should be small and are not considered here.

The model plants analyzed in Chapter 10 are not applicable to Option C because the waste amounts generated by it are below the 1,000 kg cutoff for Option C. It is expected that the average waste quantities of the largest 10 percent of the establishments in these two segments will be 1,500 kg/month (18,000 kg annually) for gasoline service stations and 1,200 kg/month (14,000 kg annually) for automotive repair shops. The large business volume of these large generators indicates smaller reductions in income than those forecasted for the model plants in Chapter 10.

Aggregate impacts on these two industries are displayed in Table 21-7 for gasoline service stations and 21-8 for automotive repair shops. The tables show that aggregate costs for both industries combined are reduced from $50.2 million under Option B to $20.9 million under Option C - more than a 50 percent reduction in costs. Additionally, the Option C waste volume exclusion exempts from regulatory compliance over 165,000 plants that were regulated under Options A and B.

## 21.4 Drum Reconditioners

The impacts of RCRA on drum reconditioners will not be materially reduced by Option C, though drum reconditioners will face slightly reduced overall costs under the option. While all of the estimated facilities are expected to be subject to regulation (generating over 1,000 kg of hazardous

### TABLE 21-7

### AGGREGATE COST OF COMPLIANCE FOR THE GASOLINE SERVICE STATION INDUSTRY ($MM)

| | OPTION A | OPTION B | OPTION C |
|---|---|---|---|
| Number of generators[a] | 118,530 | 118,530 | 13,170 |
| Costs | | | |
| Technical | 25.6 | 25.6 | 13.8 |
| Administrative[b] | 38.4 | 8.8 | 1.0[b] |
| Total | 64.6[b] | 34.4[b] | 14.8[b] |
| 1977 sales value ($MM)[c] | 40,319 | 40,319 | 40,319 |
| Costs as % of production value | 0.2% | <0.1% | <0.05% |

[a] Estimate made for 1978.

[b] First-year administrative costs are shown. Recurring administrative costs are $21.3 million for Option A, $2.3 million for Option B and $0.3 million for Option C. This reduces total cost by almost 27% for Option A, 20% for Option B and 8% for Option C in succeeding years.

### TABLE 21-8

### AGGREGATE COST OF COMPLIANCE FOR THE AUTOMOTIVE REPAIR SHOP INDUSTRY ($MM)

| | OPTION A | OPTION B | OPTION C |
|---|---|---|---|
| Number of generators | 66,900 | 66,900 | 6,690 |
| Costs | | | |
| Technical | 10.8 | 10.8 | 5.6 |
| Administrative[a] | 21.7[b] | 5.0[b] | 0.5[b] |
| Total | 32.5[b] | 15.8[b] | 6.1[b] |
| 1977 sales value[b] | 10,352 | 10,352 | 10,352 |
| Costs as % of production value | 0.3% | 0.2% | <0.16% |

[a] Estimate made for 1978.

[b] First-year administrative costs are shown. Recurring administrative costs are $12.0 million for Option A, $1.3 million for Option B and $0.1 million for Option C. This reduces total cost by almost 30% for Option A, 25% for Option B and 7% for Option C.

waste per month), administrative costs will be reduced slightly. Administrative costs represent less than 10 percent of the cost of compliance, however, so that total cost reductions under Option C are almost imperceptible.

Estimated impacts on model and worst-case drum reconditioning facilities are displayed in Table 21-9. This table shows that net income will decline 23 percent for the model firm and 36 percent for the worst-case firm. These percentages are identical to those estimated for Option B. Overall industry impacts are then displayed in Table 21-10, along with the comparable impacts of Options A and B. As can be seen from the table, compliance costs as a percent of sales are the same for each option.

Table 21-11 displays a comparative analysis of the administrative cost components for the three options. As can be seen from the table, the only reduction in cost from Option B to Option C results from reducing the manifest requirement to a bill of lading and from reducing supervisory time due to the overall simplifying of reporting requirements.

## 21.5 Chemical Wholesalers

Chemical wholesalers will face a reduced cost of compliance under Option C, primarily because smaller generators will be exempted under the 1,000 kg/month minimum. Also, a small reduction in administrative costs will result from Option C. The impacts of Option C on wholesalers are summarized in Table 21-12. The table shows a negligible reduction in cost due to reduced administrative costs. The aggregate costs of Option C are comparatively displayed to

## TABLE 21-9

## IMPACTS ON DRUM RECONDITIONING MODEL FIRMS (OPTION C)[a]

| | MODEL ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales | 1,080,000 | 1,080,000 |
| Cost of operations | 960,000 | 760,000 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 25,100 | 32,600 |
| Administrative costs[b] | 2,000 | 2,000 |
| Pretax net income | 92,900 | 61,400 |
| Pretax net income (before RCRA) | 120,000 | 96,000 |
| Decline in pretax net income under Option C | 23% | 36% |
| Decline in pretax net income under Option B | 23% | 36% |

[a] ERCO estimates.

[b] Represents estimated first-year administrative costs. Recurring annual costs are estimated at $985.

## TABLE 21-10

## AGGREGATE COST OF COMPLIANCE FOR THE DRUM RECONDITIONING INDUSTRY (1977 $MM)[a,b]

| | OPTION A | OPTION B | OPTION C |
|---|---|---|---|
| Number of Generators | 190 | 190 | 190 |
| Costs | | | |
| Technical | 7.1 | 7.1 | 7.1 |
| Administrative[c] | 0.5 | 0.4 | 0.4 |
| Total | 7.6 | 7.5 | 7.5 |
| 1977 production value | 640 | 640 | 640 |
| Costs as a percentage of production value | 1.2 | 1.2 | 1.2 |

[a] ERCO estimates.

[b] Figures are in 1977 dollars.

[c] First-year administrative costs are shown. Recurring administrative costs are $0.2 million for Options A and B and $0.1 million for Option C. This reduces total cost by less than 5% in succeeding years.

## TABLE 21-11

## ADMINISTRATIVE COSTS OF COMPLIANCE WITH RCRA FOR DRUM RECONDITIONERS[a]

| | OPTION C LABOR | | | | |
|---|---|---|---|---|---|
| | SUPV. ($25/hr) | CLERICAL ($8/hr) | OPTION C COST ($) | OPTION B COST ($) | OPTION A COST ($) |
| Section 3001 | | | | | |
| 1. Initial waste inventory | 8 | | 200 | 200 | 200 |
| 2. Documentation of waste inventory | 7 | 6 | 223 | 223 | 223 |
| Section 3002 | | | | | |
| 1. ID code application | 1 | 1/2 | 29 | 29 | 29 |
| 2. Quarterly and annual reporting | 5 | 13 | 229/yr | 229/yr | 556/yr |
| 3. Storage of manifests | - | - | 5/yr | 20/yr | 20/yr |
| 4. Manifest handling ($3/manifest, 1 manifest/mo) | - | - | - | 36/yr | 36/yr |
| 5. System design for labeling, manifesting, reporting, and identification of TSDF | 30 | 21 | 918 | 918 | 918 |
| 6. Ongoing supervision | 12 | - | 300/yr | 600/yr | 600/yr |
| 7. Maintenance of hazardous waste list and refinement of other procedures | 4 | - | 100/yr | 100/yr | 100/yr |
| Total cost | | | 2,004 | 2,355 | 2,682 |
| Recurring annual costs ($/yr) | | | 634 | 985 | 1,312 |

[a] ERCO estimates.

## TABLE 21-12

## IMPACT ON CHEMICAL WHOLESALING MODEL FIRMS (OPTION C) (WITH REGULATION)

| | MODEL FIRM ($) | WORST-CASE FIRM ($) |
|---|---|---|
| Sales[a] | 10,000,000 | 5,000,000 |
| Cost of operations and expenses | 9,319,700 | 4,865,000 |
| Incremental RCRA impacts | | |
| Technical disposal costs | 3,500 | 2,300 |
| Administrative costs[b] | 1,900 | 1,900 |
| Pretax net income | 674,900 | 130,800 |
| Pretax net income (before RCRA) | 680,300 | 135,000 |
| Decline in pretax net income under Option C | 1% | 3% |
| Decline in pretax net income under Option B | 1% | 3% |

[a] Assumes no change in price.

[b] First-year administrative costs are shown. Recurring annual costs are $600.

Options A and B in Table 21-13. This table shows reduced overall costs of Option C due to the reduction in the number of relevant generators. Impacts of Option C will be minor at the plant and industry level.

The administrative costs of compliance for Option C are displayed in Table 21-14 along with comparative costs for the other options. Costs per generator are reduced primarily as a result of the substitution of a bill of lading for the manifest required for offsite disposal and hazardous wastes.

### TABLE 21-13
### AGGREGATE COST OF COMPLIANCE FOR THE CHEMICAL WHOLESALING INDUSTRY (1977 $MM)[a]

| | OPTION A | OPTION B | OPTION C |
|---|---|---|---|
| Number of generators | 360 | 360 | 270 |
| Costs | | | |
| Technical disposal | 783 | 783 | 522 |
| Administrative | 972 | 864 | 540 |
| Total | 1,753 | 1,647 | 1,062 |
| 1977 sales (estimate) | 2,700,000 | 2,700,000 | 2,700,000 |
| Compliance as a percent of 1977 sales | <0.1% | <0.1% | <0.05% |

---

[a] ERCO estimate.

[b] Represents first-year administrative costs. Recurring administrative costs are $485,000 for Option A, $368,000 for Option B and $171,000 Option C. This reduces total cost by 30% for Options A and B and 35% for Option C in succeeding years.

## TABLE 21-14

## ADMINISTRATIVE COSTS OF COMPLIANCE WITH RCRA FOR CHEMICAL WHOLESALERS

| | OPTION C LABOR | | | | |
|---|---|---|---|---|---|
| | SUPV. ($25/hr) | CLERICAL ($8/hr) | OPTION C COST ($) | OPTION B COST ($) | OPTION A COST ($) |
| Section 3001 | | | | | |
| 1. Initial waste inventory | 8 | - | 200 | 200 | 200 |
| 2. Documentation of waste inventory | 7 | 6 | 223 | 223 | 223 |
| Section 3002 | | | | | |
| 1. ID code application | 1 | 1/2 | 29 | 29 | 29 |
| 2. Quarterly and annual reporting | 5 | 13 | 229/yr | 229/yr | 556/yr |
| 3. Storage of manifests | - | - | 5/yr | 20/yr | 20/yr |
| 4. Manifest handling ($3/manifest, 1 manifest/mo) | - | - | - | 72/yr | 72/yr |
| 5. System design for labeling, manifesting, reporting, and identification of TSDF | 28 | 20 | 860 | 918 | 918 |
| 6. Ongoing supervision | 12 | - | 300/yr | 600/yr | 600/yr |
| 7. Maintenance of hazardous waste list and refinement of other procedures | 4 | - | 100/yr | 100/yr | 100/yr |
| Total cost | | | 1,946 | 2,391 | 2,718 |
| Recurring annual costs ($/yr) | | | 634 | 1,021 | 1,349 |

[a]ERCO estimates.

Technical disposal costs are assumed to remain the same for all three options.

The number of generators could not be assessed due to insufficient data. It is likely that as many as fifty percent of the 360 estimated generators under Options A and B may generate less than the 1,000 kg/month of waste, exempting them from impact. It is presumed that those facilities already treating their waste are larger facilities and not eliminated from further consideration because of the 1,000 kg/month exclusion. For purposes of estimating aggregate costs, it has been assumed that 270 plants would be required to comply with Option C regulations, although these plants would face no additional technical disposal costs.

## 21.6 Agricultural Services

The Agricultural Services industry pesticide wastes are specifically exempted from compliance under Option C. Other hazardous wastes (notably waste oil) are not expected to amount to 1,000 kg/month, thus exempting the industry completely from Option C compliance. Some negligible costs may be incurred by firms in verifying their exemption from Option C regulations.

## 21.7 Metal and Mineral Distributors

Metal and mineral distributors faced negligible impact under Options A and B. Option C impacts will also be insignificant.

# PART IX

# METHODOLOGY

# CHAPTER TWENTY-TWO

# STUDY METHODOLOGY

Several issues concerning the basic methodology used in the study will be covered in this chapter. The details of the analysis vary considerably among the industry sections due to both differences in industry characteristics and differences in the available data. As a result, only the general format of the estimation procedures will be covered. The specific elements of the analysis are described in the separate industry sections. The issues covered here include the rationale for the use of model plants and several elements of the cost estimation procedure.

## 22.1 Model Plant Analysis

Model plants (or firms) have been described in all of the industry sections. In each case a model (average) plant and a worst-case plant were developed. The plants are defined in terms of sales volume, cost of operations, waste volumes and net income.

The model plants are useful as an analytical convenience for several reasons. First, it is not possible to construct model plants for all of the various sizes and types of firms in the different industries. The model plant is constructed to be representative of reality for the bulk of industry firms. The worst-case plant is designed to represent impacts for industry segments which are likely to face greater than

Preceding page blank

average impacts. The model and worst-case plants are designed in a fairly conservative fashion. That is, relatively pessimistic assumptions were made in the design of each plant in order not to underestimate average or worst-case impacts.

Model plants were a necessary tool given the lack of available information on many of the industries studied. Any analysis performed with only aggregated industry data would have been restricted to drawing very general conclusions. However, average firm characteristics could be defined with relative ease based on a number of discussions with industry executives. Relevant data at the firm level which could be collected included waste volumes, firm revenues and, in most cases, average net income.

## 22.2 Assessment of Industry Impacts

A summary table is provided for each industry with estimates of the likelihood of plant closures, price changes and other impacts. The interpretation given to each of the terms used for describing the likelihood of plant shutdowns is provided in Table 22-1 below.

Job losses were assumed to follow the pattern of plant closures. No further attempt was made to determine the extent of the job loss problem, such as the probable employment prospects of discharged workers.

Production cutbacks were not expected in any of the segments studied. Forecasted plant shutdowns were anticipated due to the combination of RCRA impacts and competitive pressures (namely an inability to raise prices). In that environment, remaining industry firms are likely to absorb

TABLE 22-1

DESCRIPTIONS USED FOR ESTIMATING PLANT SHUTDOWNS

| TERM | INTERPRETATION |
|---|---|
| Unlikely | Less than 25% chance that 10% of the industry firms will close |
| Possible | 25-50% chance that 10% of the industry firms will close |
| Probable | 50-75% chance that 10% of the industry firms will close |
| Likely | Over 75% chance that 10% of the industry firms will close |

the additional business volume, making production cutbacks a small, short-term problem.

No price impacts were forecasted to be greater than 3 percent. These increases were all characterized as small. None of the industries studied face highly elastic demand curves. As a result, demand reductions were also characterized as small.

Balance of payments effects were negligible with the possible exception of the electric utility industry. A description of balance of payments effects in that case is provided in Chapter Four.

## 22.3 Cost Estimates

### 22.3.1 Technical Costs

Original technical cost estimates were made for the electric utilities, gasoline service stations and automotive repair shops. A variety of other sources were used for cost estimates and these are described as they are presented in each industry section. Hazardous waste landfill costs from the Battelle study were used to develop costs for several industries (Battellè Columbus Laboratories, Cost of Compliance with Hazardous Waste Management Regulations, EPA, May 1978).

### 21.3.2 Administrative Costs

A variety of costs were grouped under the general title of administrative costs. The cost estimates were taken from a study by Arthur D. Little (Preliminary Integrated Economic Impact Assessment of Hazardous Waste Management Regulations, EPA, October 1978). A number of judgments were made as to the applicability of specific administrative tasks to each industry. Also, estimates were changed in many cases to take into account the specific costs as they would apply to a given industry.

Many of the nontechnical compliance costs would be incurred once, presumably in the first year of regulation. For the large industries, electric utilities and paper and pulp, the first-year only costs were annualized over a 10-year period and added to recurring-year costs. Assuming a 10 percent interest rate, the appropriate charge factor is 0.1627. For the other industries, costs were not annualized. Most of the cost impacts were described in terms of first-year costs, although recurring-year costs were also presented.

## 22.4 Limits of the Analysis

The estimates made in this study were based on data derived from a variety of sources. Each of the estimates and the basic data sources involve some degree of error. No estimation was made of the total probable error range for the cost estimates.

The waste stream designations made are also approximate. Available data in some cases were not sufficient to clearly assign a waste into the "hazardous" or "nonhazardous" category. Conclusions were drawn based upon the existing knowledge. This study was not designed to make a final identification of hazardous wastes in the study industries.

This study involves static analysis of the costs of compliance with regulations. It was assumed that access to all necessary treatment or disposal facilities would be available as needed at the estimated price or cost. Thus, for example, no estimation was made of the effect of increased demand due to regulation on the cost of services at hazardous waste facilities. Also no forecast was made of the future availability of facilities.

The effects of certain aspects of the RCRA regulations could not be considered. The stipulation that disposal sites not be located in a 100-year floodplain was not considered in the cost estimates. Also, the possibility that firms can meet the required level of control with alternative treatments or disposal techniques was not considered.

Industry impacts were approximated with the analysis of model and worst-case plants. This procedure involves a measure of errors due to the variability of industry firms.

# APPENDIX

Preceding page blank

# APPENDIX A

## COST ESTIMATION METHODOLOGY FOR ELECTRIC UTILITIES

The cost estimates will be shown in the order in which they are presented in the text. Little discussion is provided for the estimated disposal costs for sludge and ash at the model facility since these costs are derived directly from other sources. The source material for cost estimation consists of the following:

1. The Economics of Disposal of Lime/Limestone Scrubbing Wastes - Untreated and Chemically Treated Wastes, J.W. Barrier, H.L. Faucett, and L.J. Henson.
2. State-of-the-Art of FGD Sludge Fixation, Michael Baker, Jr., Associates.
3. Cost of Compliance with Hazardous Waste Management Regulations, Battelle Columbus Laboratories, D.A. Sharp, J.A. Gurklis, and V.S. Brueggemeyer.

### A.1 Cost of Disposal of Ash and Sludge - Option A

The costs for the unlined pond, artificial liner, and the chemical stabilization option were derived from the TVA study. The costs of "additional elements" were derived from the Battelle study. Specifically, the costs for the monitoring wells and leachate treatment equipment were derived directly from the latter report. The cost of the collection system

Preceding page blank

was scaled upwards due to the larger size of the sludge disposal facility.

The costs of the pond with a 10-foot clay liner were derived from information provided by personnel at TVA, Muscle Shoals, Alabama. The information was generated in a separate run of the cost estimation model being used at TVA.

Costs of the pond with a 5-foot clay liner were linearly extrapolated from the costs for a 1-foot and 10-foot liner. This estimate was then combined with the estimated liner costs used in the TVA study. It was assumed, in this case, that pond dimensions were the same as those of the basic pond in the TVA study (407 acres). Modification of this assumption would reduce the overall size of the investment. That is, for ponds with expensive liner requirements, use of a smaller, deeper pond reduces the total investment.

A small discrepancy exists in the cost per metric ton due to variance in the exact tonnage to be disposed. Specifically, the untreated and treated disposal methods result in slightly different amounts of waste material. This variability may cause a small discrepancy in converting from the estimates presented here to the TVA study.

The chemical fixation option requires a smaller capital investment but larger operating costs. Thus the capital investment appears as a credit but incremental annual revenue requirements are shown.

## A.2 Retrofit Costs for Ash Disposal - Option B

The cost estimation procedure is derived from that included in the EPRI study, although a number of changes were made for the retrofitting case. For the landfill operation, the ash was mixed with water (one-sixth water content) and trucked to the disposal area. The estimate is for disposal from a 500-MW plant with a remaining 20-year life. The operating profile for the plant was described above in Table 3-14. Bottom ash and fly ash are assumed to be disposed of jointly. Calculations are shown below with notes made for certain elements.

### SITE DIMENSIONS

| | |
|---|---|
| Ash production (dry weight)[1]: | |
| Fly ash | 24.5 MT/hr |
| Bottom ash | 6.1 MT/hr |
| Annual production (2,875 hr/yr): | 88,007 MT<br>(97,031 tons/yr) |
| Wet weight (the ratio of water to solids is 0.2) | 105,609 MT<br>(116,438 tons) |
| Wet weight (20 yr) | 2,112,176 MT<br>(2,328,750 tons) |
| Total volume: 1,440 kg/m$^3$ (90 lb/ft$^3$) | 1,467,323 m$^3$<br>(1,917,791 yd$^3$ |
| Area at mean depth of 12.2 m (40 ft) | 120,245 m$^2$<br>(143,834 yd$^2$ |
| Square site dimensions | 347 m x 347 m<br>(380 yd x 380 yd) |
| Total disposal site requirements[2] | 576 m x 576 m<br>(630 yd x 630 yd) |
| Area of fill[3] | 154,576 m$^2$<br>(184,900 yd$^2$) |

## SITE COSTS

| | |
|---|---|
| Land (82 acres @ $3,500) | $287,000 |
| Storm & diversion drains[4] | 20,000 |
| | 307,000 |
| Owner's expense (includes 25 percent for contingency and 20 percent for in-house engineering design cost)[5] | 153,500 |
| Total site costs | $460,500 |

## OPERATING AND MAINTENANCE COSTS

| | |
|---|---|
| Operating and maintenance costs | |
| Ash loading and transport ($0.75/ton mile for 2 miles) | $174,656 |
| Disposal/clear land (1/20 of fill at $850/acre) | 1,750 |
| Strip and clear topsoil[6] 1,000 yd @ $0.50 | 500 |
| Underdrain[7] | 5,700 |
| Place and compact fill (1/20 of volume at $\$1.25/\text{yd}^3$ | 119,862 |
| Daily cover (60 $\text{yd}^2$/day)[8] | 11,700 |
| Total | $314,078 |

## ANNUAL REVENUE REQUIREMENTS

| | |
|---|---|
| Landfill site costs | $307,000 |
| Capital charge factor[9] | x 0.186 |
| Annual charges | 85,653 |
| Operating and maintenance | 314,078 |
| Annual revenue requirements/ton | $ 4.34 MT<br>4.12/ton |

## LINER COSTS

### Clay liners

| | |
|---|---|
| 1 ft over 184,900 yd$^2$ @ \$2.50/yd$^3$ of clay | \$154,083 |
| Owner's expense | x 1.5 |
| Total investment | 231,125 |
| Capital charge factor | x 0.186 |
| Annual revenue requirements | \$ 42,989 |
| 5 ft over 184,900 yd$^2$ @ \$2.50/yd$^3$ of clay | \$ 770,416 |
| Owner's expense | x 1.5 |
| Total investment | 1,155,624 |
| Capital charge factor | x 0.186 |
| Annual revenue requirements | \$ 214,946 |
| 10 ft over 184,900 yd$^2$ @ \$2.50/yd$^3$ of clay | \$1,540,833 |
| Owner's expense | x 1.5 |
| Total investment | 2,311,250 |
| Capital charge factor | x 0.186 |
| Annual revenue requirements | \$ 429,892 |

## ARTIFICIAL LINERS

| | |
|---|---|
| Approximately 30 mils thickness over 184,900 yd$^2$ @ \$4.50/yd$^2$ | \$ 832,050 |
| Owner's expense | x 1.5 |
| Total investment | 1,248,075 |
| Capital charge factor | x 0.186 |
| Annual revenue requirements | \$ 232,142 |

## CLOSURE OF OLD SITE

| | |
|---|---|
| Clay cap 6 in. over 847,000 yd$^2$ (175 acres)$^{10}$ @ \$2.50 yd$^3$ | \$ 352,917 |
| Owner's expense | x 1.5 |
| Total investment | 529,375 |
| Capital charge factor | x 0.186 |
| Annual revenue requirements | \$ 98,464 |
| Soil cover on old site 18 in. over 847,000 yd$^2$ @ \$0.45/yd$^3$ | \$ 190,575 |
| Owner's expense | x 1.5 |
| Total investment | 285,862 |
| Capital charge factor | x 0.186 |
| Annual revenue requirements | \$ 53,170 |
| Total closure (ARR) | \$ 151,634 |

## NOTES TO COST CALCULATIONS IN A.2

1. Waste generation rates were derived from the model plant characteristics. Thus the assumed ash content is 16 percent, and the split factor is 80:20.

2. Site requirements allow for a buffer zone of 100 yd on each side of the fill. The EPRI study used a 175-yd zone. The latter estimate appeared to be excessive and was reduced.

3. The sides of the landfill are assumed to be sloped. The sloping is assumed to add 25 yd to each side of the fill area. Thus the fill area has larger dimensions than those of a square site.

4. Cost estimate was taken unchanged from the EPRI report.

5. The calculation of owner's expense was taken unchanged from the EPRI study. Calculations of owner's expense are only moderately smaller in the TVA model.

6. Costs were derived from the EPRI report and reduced due to the smaller size of landfill designed here.

7. Costs were derived from the EPRI report and reduced due to the smaller size of landfill designed here.

8. The annual volume of ash was divided by the number of working days (260). It was then assumed that ash would be disposed of in 10-ft layers. On this basis, an estimated 117 yd$^2$ of surface area would be filled per day. A 6-in. cover of soil per day would require 60 yd$^3$ per day of soil. A cost of $0.75 per yd$^3$ was used.

9. Annual revenue requirements for capital investment components were assumed to be the following:

| | |
|---|---|
| 7.0 | percent depreciation |
| 8.6 | percent average cost of capital and taxes |
| 3.0 | percent maintenance |
| 18.6 | percent |

10. One estimate of optimal pond size for fly ash disposal from a 500-MW plant is 225 acres. This estimate was reduced to take into account the incomplete utilization of the pond. (Based on personal communication between John Eyraud of ERCO and Robert Torstrick of TVA.)

## A.3 Cost of Disposal of Ash and Sludge - Option B

Cost estimates were derived directly from the TVA and Battelle studies.

## A.4 Retrofit Costs for Ash Disposal - Option B

These retrofit costs are only a subset of those described above in Section A.2.

## A.5 Worst-Case Cost Estimates

The worst-case utility is different from the model firm in three respects. The load factor for the remaining plant life is set at 60 percent, the coal ash content is 20 percent, and the ash is transported 5 miles. Alternatively, the scale of the disposal operations is consistent with those of a plant twice as large with a 30 percent load factor. Other combinations of load factors and ash contents are, of course, also possible. Calculations follow the format of those in Section A.2.

## A.6 Aggregate Disposal Costs

The assumptions used in estimating aggregate compliance costs are described in Table A-1. The methodology of estimation was the same for both RCRA options.

Retrofit costs were used to estimate the incremental costs of compliance for the total coal ash quantities for 1977. For 1985, it was assumed that an amount of ash equivalent in

## TABLE A-1

## ASSUMPTIONS FOR CALCULATION OF AGGREGATE COSTS

| ITEM | ASSUMPTION | SOURCE |
|---|---|---|
| Coal ash generation | | |
| 1977 | 60.3 million MT (dry) | Table 3-14 |
| 1985 | 97.6 million MT (dry) | Table 3-14 |
| Oil ash generation | | |
| 1977 | 20,000 MT (dry) | ERCO estimate |
| 1985 | 30,000 MT (dry) | ERCO estimate |
| Sludge generation | | |
| 1977 | 3.7 million MT (dry) | Table 3-14 |
| 1985 | 28.1 million MT (dry) | Table 3-14 |
| Retrofit cost (ash) | | |
| Option A | $8.48 per MT | Table 3-22 |
| Option B | N/A | N/A |
| New plant incremental cost (sludge or sludge and ash combined) | | |
| Option A | $6.46 per MT | Table 3-21 |
| Option B | $6.46 per MT | Table 3-26 |
| Administrative cost per facility (onsite) | | |
| Option A | $294,000 | Table 3-28 |
| Option B | $99,000 | Table 3-29 |

TABLE A-1 (CONTINUED)

| ITEM | ASSUMPTION | SOURCE |
|---|---|---|
| Number of faciliites (onsite) | | |
| 1977 | 400 | ERCO estimate |
| 1985 | 450 | ERCO estimate |
| Administrative cost per facility (offsite) | | |
| Option A | $13,470 | Table 3-30 |
| Option B | $13,126 | Table 3-30 |
| Extent of productive use of coal ash | | |
| Option A | 10 percent | ERCO estimate |
| Option B | 20 percent | ERCO estimate |
| Extent of productive use of oil ash | 75 percent | ERCO estimate |

weight to the amount of sludge generated would be disposed of in new facilities. That is, new plant incremental costs ($6.39/MT) were assumed to apply to 28.1 million MT each of ash and sludge for 1985 costs. This procedure, although admittedly arbitrary, provided a rough proxy of the amount of ash which would be generated by new plants. This procedure was used for two reasons. First, ash and sludge quantities in the model plant were roughly equivalent. Second, most of the sludge will be generated at plants brought on-line after the implementation of RCRA, thus the higher retrofitting cost would not apply.

It was assumed that under Option A, the commercial utilization of ash would fall to one-half of its existing rate of utilization (10 percent down from 20 percent). Representatives of the ash industry are concerned about the effect of the "hazardous waste" label on the productive utilization. Under Option B, no effect on commercial utilization was assumed.

μσ 1871
SW-182c